KVGC202

Technical Manual

Voltage Regulating Control Relays

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GRID

ALSTOM

SAFETY SECTION

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STANDARD SAFETY STATEMENTS AND EXTERNAL LABEL INFORMATION FOR ALSTOM GRID EQUIPMENT

1. INTRODUCTION

This Safety Section and the relevant equipment documentation provide full information on safe handling, commissioning and testing of this equipment. This Safety Section also includes reference to typical equipment label markings.

The technical data in this Safety Section is typical only, see the technical data section of the relevant equipment documentation for data specific to a particular equipment.

Before carrying out any work on the equipment the user should be familiar with the contents of this Safety Section and the ratings on the equipment's rating label.

Reference should be made to the external connection diagram before the equipment is installed, commissioned or serviced.

Language specific, self-adhesive User Interface labels are provided in a bag for some equipment.

2. HEALTH AND SAFETY

The information in the Safety Section of the equipment documentation is intended to ensure that equipment is properly installed and handled in order to maintain it in a safe condition.

It is assumed that everyone who will be associated with the equipment will be familiar with the contents of this Safety Section, or the Safety Guide (SFTY/4L M).

When electrical equipment is in operation, dangerous voltages will be present in certain parts of the equipment. Failure to observe warning notices, incorrect use, or improper use may endanger personnel and equipment and also cause personal injury or physical damage.

Before working in the terminal strip area, the equipment must be isolated.

Proper and safe operation of the equipment depends on appropriate shipping and handling, proper storage, installation and commissioning, and on careful operation, maintenance and servicing. For this reason only qualified personnel may work on or operate the equipment.

Qualified personnel are individuals who:

- Are familiar with the installation, commissioning, and operation of the equipment and of the system to which it is being connected;
- Are able to safely perform switching operations in accordance with accepted safety engineering practices and are authorized to energize and de-energize equipment and to isolate, ground, and label it;
- Are trained in the care and use of safety apparatus in accordance with safety engineering practices;
- Are trained in emergency procedures (first aid).

The equipment documentation gives instructions for its installation, commissioning, and operation. However, the manuals cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact the appropriate Alstom Grid technical sales office and request the necessary information.

3. SYMBOLS AND LABELS ON THE EQUIPMENT

For safety reasons the following symbols which may be used on the equipment or referred to in the equipment documentation, should be understood before it is installed or commissioned.

3.1 Symbols

Caution: refer to equipment documentation

Caution: risk of electric shock

Protective Conductor (*Earth) terminal

Functional/Protective Conductor (*Earth) terminal.

Note: This symbol may also be used for a Protective Conductor (Earth) Terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.

*__NOTE:__ THE TERM EARTH USED THROUGHOUT THIS TECHNICAL MANUAL IS THE DIRECT EQUIVALENT OF THE NORTH AMERICAN TERM GROUND.

3.2 Labels

See Safety Guide (SFTY/4L M) for typical equipment labeling information.

4. INSTALLING, COMMISSIONING AND SERVICING

Equipment connections

Personnel undertaking installation, commissioning or servicing work for this equipment should be aware of the correct working procedures to ensure safety.

The equipment documentation should be consulted before installing, commissioning, or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

The clamping screws of all terminal block connectors, for field wiring, using M4 screws shall be tightened to a nominal torque of 1.3 Nm.

Equipment intended for rack or panel mounting is for use on a flat surface of a Type 1 enclosure, as defined by Underwriters Laboratories (UL).

Any disassembly of the equipment may expose parts at hazardous voltage, also electronic parts may be damaged if suitable electrostatic voltage discharge (ESD) precautions are not taken.

If there is unlocked access to the rear of the equipment, care should be taken by all personnel to avoid electric shock or energy hazards.

Voltage and current connections shall be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety.

Watchdog (self-monitoring) contacts are provided in numerical relays to indicate the health of the device. Alstom Grid strongly recommends that these contacts are hardwired into the substation's automation system, for alarm purposes.

To ensure that wires are correctly terminated the correct crimp terminal and tool for the wire size should be used.

The equipment must be connected in accordance with the appropriate connection diagram.

Protection Class I Equipment

- Before energizing the equipment it must be earthed using the protective conductor terminal, if provided, or the appropriate termination of the supply plug in the case of plug connected equipment.
- The protective conductor (earth) connection must not be removed since the protection against electric shock provided by the equipment would be lost.
- When the protective (earth) conductor terminal (PCT) is also used to terminate cable screens, etc., it is essential that the integrity of the protective (earth) conductor is checked after the addition or removal of such functional earth connections. For M4 stud PCTs the integrity of the protective (earth) connections should be ensured by use of a locknut or similar.

The recommended minimum protective conductor (earth) wire size is 2.5 mm² (3.3 mm² for North America) unless otherwise stated in the technical data section of the equipment documentation, or otherwise required by local or country wiring regulations.

The protective conductor (earth) connection must be low-inductance and as short as possible.

All connections to the equipment must have a defined potential. Connections that are pre-wired, but not used, should preferably be grounded when binary inputs and output relays are isolated. When binary inputs and output relays are connected to common potential, the pre-wired but unused connections should be connected to the common potential of the grouped connections.

Before energizing the equipment, the following should be checked:

- Voltage rating/polarity (rating label/equipment documentation);
- CT circuit rating (rating label) and integrity of connections;
- Protective fuse rating;
- Integrity of the protective conductor (earth) connection (where applicable);
- Voltage and current rating of external wiring, applicable to the application.

Accidental touching of exposed terminals

If working in an area of restricted space, such as a cubicle, where there is a risk of electric shock due to accidental touching of terminals which do not comply with IP20 rating, then a suitable protective barrier should be provided.

Equipment use

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Removal of the equipment front panel/cover

Removal of the equipment front panel/cover may expose hazardous live parts, which must not be touched until the electrical power is removed.

UL and CSA/CUL listed or recognized equipment

To maintain UL and CSA/CUL Listing/Recognized status for North America the equipment should be installed using UL and/or CSA Listed or Recognized parts for the following items: connection cables, protective fuses/fuseholders or circuit breakers, insulation crimp terminals, and replacement internal battery, as specified in the equipment documentation.

For external protective fuses a UL or CSA Listed fuse shall be used. The Listed type shall be a Class J time delay fuse, with a maximum current rating of 15 A and a minimum d.c. rating of 250 Vd.c. for example type AJT15.

Where UL or CSA Listing of the equipment is not required, a high rupture capacity (HRC) fuse type with a maximum current rating of 16 Amps and a minimum d.c. rating of 250 Vd.c. may be used, for example Red Spot type NIT or TIA.

Equipment operating conditions

The equipment should be operated within the specified electrical and environmental limits.

Current transformer circuits

Do not open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation. Generally, for safety, the secondary of the line CT must be shorted before opening any connections to it.

For most equipment with ring-terminal connections, the threaded terminal block for current transformer termination has automatic CT shorting on removal of the module. Therefore external shorting of the CTs may not be required, the equipment documentation should be checked to see if this applies.

For equipment with pin-terminal connections, the threaded terminal block for current transformer termination does NOT have automatic CT shorting on removal of the module.

External resistors, including voltage dependent resistors (VDRs)

Where external resistors, including voltage dependent resistors (VDRs), are fitted to the equipment, these may present a risk of electric shock or burns, if touched.

Battery replacement

Where internal batteries are fitted they should be replaced with the recommended type and be installed with the correct polarity to avoid possible damage to the equipment, buildings and persons.

Insulation and dielectric strength testing

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

Insertion of modules and pcb cards

Modules and PCB cards must not be inserted into or withdrawn from the equipment whilst it is energized, since this may result in damage.

Insertion and withdrawal of extender cards

Extender cards are available for some equipment. If an extender card is used, this should not be inserted or withdrawn from the equipment whilst it is energized. This is to avoid possible shock or damage hazards. Hazardous live voltages may be accessible on the extender card.

External test blocks and test plugs

Great care should be taken when using external test blocks and test plugs such as the MMLG, MMLB and MiCOM P990 types, hazardous voltages may be accessible when using these. *CT shorting links must be in place before the insertion or removal of MMLB test plugs, to avoid potentially lethal voltages.

*Note: When a MiCOM P992 Test Plug is inserted into the MiCOM P991 Test Block, the secondaries of the line CTs are automatically shorted, making them safe.

Fiber optic communication

Where fiber optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

Cleaning

The equipment may be cleaned using a lint free cloth dampened with clean water, when no connections are energized. Contact fingers of test plugs are normally protected by petroleum jelly, which should not be removed.

5. DE-COMMISSIONING AND DISPOSAL

De-commissioning

The supply input (auxiliary) for the equipment may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the equipment (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to de-commissioning.

Disposal

It is recommended that incineration and disposal to water courses is avoided. The equipment should be disposed of in a safe manner. Any equipment containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation, may apply to the disposal of the equipment.

6. TECHNICAL SPECIFICATIONS FOR SAFETY

Unless otherwise stated in the equipment technical manual, the following data is applicable.

6.1 Protective fuse rating

The recommended maximum rating of the external protective fuse for equipments is 16A, high rupture capacity (HRC) Red Spot type NIT, or TIA, or equivalent. The protective fuse should be located as close to the unit as possible.

DANGER - CTs must NOT be fused since open circuiting them may produce lethal hazardous voltages.

6.2 Protective class

IEC 60255-27: 2005	Class I (unless otherwise specified in the equipment documentation).
EN 60255-27: 2005	This equipment requires a protective conductor (earth) connection to ensure user safety.

6.3 Installation category

IEC 60255-27: 2005	Installation category III (Overvoltage Category III):
EN 60255-27: 2005	Distribution level, fixed installation.
	Equipment in this category is qualification tested at 5 kV peak, 1.2/50 µs, 500 Ω, 0.5 J, between all supply circuits and earth and also between independent circuits.

6.4 Environment

The equipment is intended for indoor installation and use only. If it is required for use in an outdoor environment then it must be mounted in a specific cabinet of housing which will enable it to meet the requirements of IEC 60529 with the classification of degree of protection IP54 (dust and splashing water protected).

Pollution Degree - Pollution Degree 2 Compliance is demonstrated by reference to safety Altitude - Operation up to 2000m standards.

IEC 60255-27:2005

EN 60255-27: 2005

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1. INTRODUCTION

1.1 Introduction

The KVGC202 relay is the K Range version of the MVGC voltage regulating relay based on the K Range series 2 relays. The KVGC202 has retained the existing functionality of the MVGC relay and additional functionalities and features have been added to the relay, to allow greater flexibility.

The KVGC202 relay controls a tap changer to regulate the system voltage within the finite limits set on the KVGC202 to provide a stable voltage to electrically powered equipment connected to the power system.

As with the K Range range of protection relays the KVGC202 voltage regulating relay brings numerical technology to the successful MIDOS range of protection relays. Fully compatible with the existing designs and sharing the same modular housing concept, the relay offers more comprehensive control for demanding applications.

The KVGC202 relay includes an extensive range of control and data gathering functions to provide a completely integrated system of control, instrumentation, data logging and event recording. The relays have a user-friendly 32 character liquid crystal display (LCD) with 4 push-buttons which allow menu navigation and setting changes. Also, by utilising the simple 2-wire communication link, all of the relay functions can be read, reset and changed on demand from a local or remote personal computer (PC), loaded with the relevant software.

Integral features in the KVGC relays include inverse or definite time operating characteristic, line drop compensation, undervoltage and overvoltage detectors, blocked tap change operation, overcurrent, undercurrent and circulating current supervision, load shedding/boosting capabilities, reverse reactance or circulating current compensation for parallel transformers to minimise circulating current tap position indication and two alternative groups of predetermined settings. The relays also have integral serial communication facilities via K-Bus.

With enhanced versatility, reduced maintenance requirements and low burdens, the KVGC202 relay provide a more advanced solution to electrically powered equipment.

This manual details the menu, functions and logic for the KVGC202 relays although general descriptions, external connections and some technical data applies equally to the K Range relays.

1.2 Using the manual

This manual provides a description of the KVGC202 voltage regulating relay. It is intended to guide the user through application, installation, setting and commissioning of the relays.

The manual has the following format:

Chapter 1. Introduction

An introduction on how to use this manual

Chapter 2. Handling and Installation

Precautions to be taken when handling electronic equipment.

Chapter 3. Relay Description

A detailed description of the features of the KVGC202 relays.

Chapter 4. Application of Control Functions

An introduction to the applications of the relays and special features provided.

Chapter 5.	Relay settings A description of setting ranges and factory settings.
Chapter 6.	Measurements, Records and Alarms How to customise the measurements and use the recording features.
Chapter 7.	Control Functions and Serial Communications Hints on using the serial communication feature.
Chapter 8.	Technical Data Comprehensive details on the ratings, setting ranges and specifications etc.
Chapter 9.	Commissioning, Problem Solving & Maintenance A guide to commissioning, problem solving and maintenance.
Appendix	Appendices include relay time characteristic curve, logic diagram, connection diagrams and commissioning test records.
Index	Provides the user with page references for quick access to selected topics.

1.3 Models available

The following models are available:

KVGC 202 01N21GE_ 24–125V rated model

KVGC 202 01N51GE_ 48–250V rated model

2. HANDLING AND INSTALLATION

2.1 General considerations

2.1.1 Receipt of product

Although the product is generally of robust construction, careful treatment is required prior to installation on site. Upon receipt, the product should be examined immediately, to ensure no damage has been sustained in transit. If damage has been sustained during transit, a claim should be made to the transport contractor, and an ALSTOM Grid SAS representative should be promptly notified. Products that are supplied unmounted and not intended for immediate installation should be returned to their protective polythene bags.

2.1.2 Electrostatic discharge (ESD)

The product uses components that are sensitive to electrostatic discharges. The electronic circuits are well protected by the metal case and the internal module should not be withdrawn unnecessarily. When handling the module outside its case, care should be taken to avoid contact with components and electrical connections. If removed from the case for storage, the module should be placed in an electrically conducting antistatic bag.

There are no setting adjustments within the module and it is advised that it is not unnecessarily disassembled. Although the printed circuit boards are plugged together, the connectors are a manufacturing aid and not intended for frequent dismantling; in fact considerable effort may be required to separate them. Touching the printed circuit board should be avoided, since complementary metal oxide semiconductors (CMOS) are used, which can be damaged by static electricity discharged from the body.

2.2 Handling of electronic equipment

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage, which often may not be immediately apparent but the reliability of the circuit will have been reduced.

The electronic circuits are completely safe from electrostatic discharge when housed in the case. Do not expose them to risk of damage by withdrawing modules unnecessarily.

Each module incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to withdraw a module, the precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

Before removing a module, ensure that you are at the same electrostatic potential as the equipment by touching the case.

Handle the module by its frontplate, frame or edges of the printed circuit board. Avoid touching the electronic components, printed circuit track or connectors.

Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.

Place the module on an antistatic surface, or on a conducting surface which is at the same potential as yourself.

Store or transport the module in a conductive bag.

If you are making measurements on the internal electronic circuitry of an equipment in service, it is preferable that you are earthed to the case with a conductive wrist strap. Wrist straps should have a resistance to ground between 500k–10M ohms. If a wrist strap is not available, you should maintain regular contact with the case to prevent a build-up of static. Instrumentation which may be used for making measurements should be earthed to the case whenever possible.

More information on safe working procedures for all electronic equipment can be found in BS5783 and IEC 60147–OF. It is strongly recommended that detailed investigations on electronic circuitry, or modification work, should be carried out in a Special Handling Area such as described in the above-mentioned BS and IEC documents.

2.3 Mounting

Products are dispatched, either individually, or as part of a panel/rack assembly. If loose products are to be assembled into a scheme, then construction details can be found in Publication R7012. If an MMLG test block is to be included it should be positioned at the right hand side of the assembly (viewed from the front). Modules should remain protected by their metal case during assembly into a panel or rack. The design of the relay is such that the fixing holes are accessible without removal of the cover. For individually mounted units, an outline diagram is normally supplied showing the panel cut-outs and hole centres. These dimensions will also be found in Publication R6520.

2.4 Unpacking

Care must be taken when unpacking and installing the products so that none of the parts are damaged, or the settings altered and they must only be handled by skilled persons. The installation should be clean, dry and reasonably free from dust and excessive vibration. The site should be well lit to facilitate inspection. Modules that have been removed from their cases should not be left in situations where they are exposed to dust or damp. This particularly applies to installations which are being carried out at the same time as construction work.

2.5 Storage

If products are not to be installed immediately upon receipt they should be stored in a place free from dust and moisture in their original cartons. Where de-humidifier bags have been included in the packing they should be retained. The action of the de-humidifier crystals will be impaired if the bag has been exposed to ambient conditions and may be restored by gently heating the bag for about an hour, prior to replacing it in the carton.

Dust which collects on a carton may, on subsequent unpacking, find its way into the product; in damp conditions the carton and packing may become impregnated with moisture and the de-humidifier will lose its efficiency.

Storage temperature –25°C to +70°C.

3. RELAY DESCRIPTION

3.1 Relay description

The KVGC202 voltage regulating relay use numerical techniques to derive control functions. Six multiplexed analogue inputs are used, sampled eight times per power frequency cycle. The Fourier derived power frequency component returns the rms value of the measured quantity. To ensure optimum performance, frequency tracking is used. The channel that is tracked is chosen, in order, from Vbc (low accuracy), external TPI supply and IL.

Eight output relays can be programmed to respond to any of the control functions and eight logic inputs can be allocated to control functions. The logic inputs are filtered to ensure that induced ac current in the external wiring to these inputs does not cause an incorrect response. Software masks further enable the user to customise the product for their own particular applications. They select/interconnect the various control elements and replace the interconnections that were previously used between the cases of relays that provided discrete control functions. An option is provided to allow testing of the output relays via the menu structure.

The relay is powered from either a dc, or an ac, auxiliary which is transformed by a wide ranging dc/dc converter within the relay. This provides the electronic circuits with regulated and galvanically isolated supply rails. The power supply also provides a regulated and isolated field voltage to energise the logic inputs.

An interface on the front of the relay allows the user to navigate through the menu to access data, change settings and reset flags etc. As an alternative the relay can be connected to a computer via the serial communication port and the menu accessed on-line. This provides a more friendly and intuitive method of setting the relay, as it allows a whole column of data to be displayed at one time instead of just a single menu cell. Computer programs are also available that enable setting files to be generated off-line and these files can then be down loaded to the relay via the serial communication port.

In addition to control functions the relay can display all the values that are measured and many additional ones that are calculated. Useful time stamped data for post event analysis is stored in event records. This data is available via a serial communication port for access locally and/or remotely, with a computer. Remote control actions can also be made and to this end K Range relays have been integrated into SCADA systems.

KVGC202 relay provide the user with the flexibility to customise the relay for their particular applications. They provide many additional features that would be expensive to produce on an individual basis and when the low installation costs are taken into account it will be seen to provide an economic solution for tap change control.

3.2 User interface

The front plate of the relay provides a man machine interface, providing the user with a means of entering settings to the relay, displaying measured values and alarms.

3.2.1 Frontplate layout

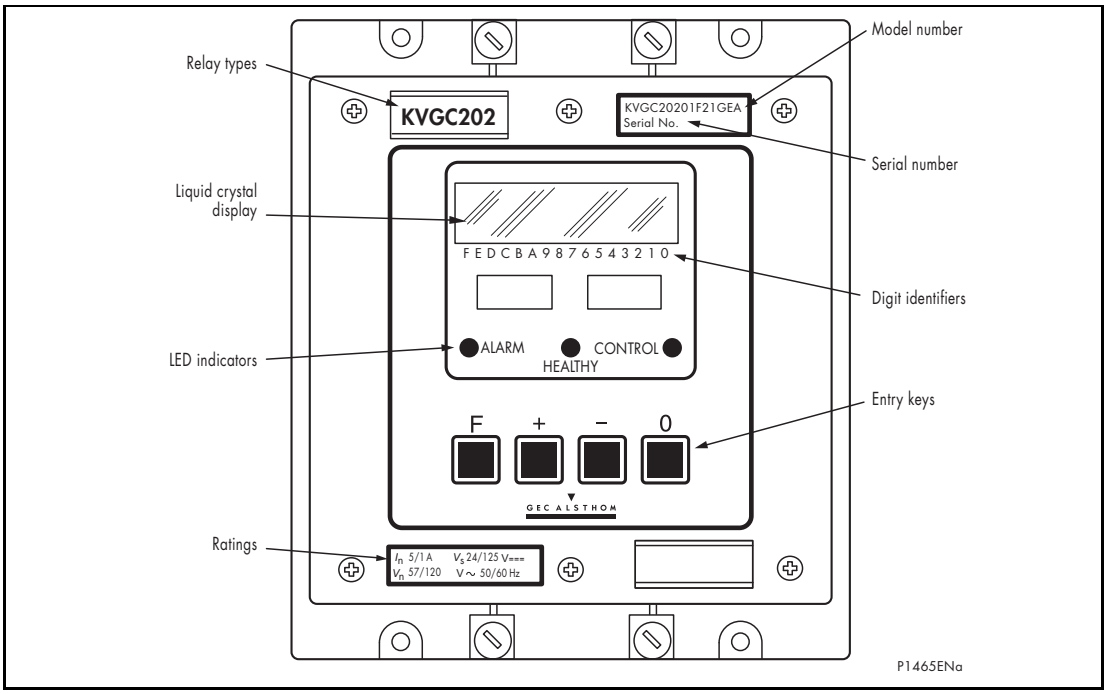


Figure 1: Front plate layout

The front plate of the relay carries a liquid crystal display (LCD) on which data such as settings, measured values and information for the control conditions can be viewed. The data is accessed through a menu system. The four keys [F]; [+]; [–] & [0] are used to move around the menu, select the data to be accessed and enter settings. Three light emitting diodes LEDs indicate alarm, healthy and control conditions.

A label at the top corner identifies the relay by both its model number and serial number. This information uniquely specifies the product and is required when making any enquiry to the factory about a particular relay. In addition, there is a rating label in the bottom corner which gives details of the auxiliary voltage and current ratings. Two handles, one at the top and one at the bottom of the front plate, will assist in removing the module from the case.

3.2.2 LED indications

The three LEDs provide the following functions:

GREEN LED Labelled as ‘HEALTHY’ indicates the relay is powered up and running. In most cases it follows the watchdog relay.

YELLOW LED Labelled as ‘ALARM’ indicates alarm conditions that have been detected by the relay during its self checking routine or supervision control. The alarm lamp flashes when the password is entered (password inhibition temporarily overridden).

RED LED Labelled as ‘CONTROL’ indicates a tap change that has been issued by the relay and is lit for a period, tPULSE. When lit permanently it indicates tap change operation (Raise and Lower) is blocked or the inter-tap delay is set to zero. The control lamp flashes to indicate that one or more system fault indications are present.

3.2.3 Keypad

The four keys perform the following functions:

[F] – function select/digit select key/next column

[+] – put in setting mode/increment value/accept key/previous column

[–] – put in setting mode/decrement value/reject key/next column

[0] – reset/escape/change default display key

Note: Only the [F] and [0] keys are accessible when the relay cover is in place.

3.2.4 Liquid crystal display

The liquid crystal display has two lines, each of sixteen characters. A back-light is activated, when any key on the front plate is momentarily pressed and will remain lit until ten minutes after the last key press. This enables the display to be read in all conditions of ambient lighting. The back-light will automatically switch off after one minute of keypad inactivity.

The numbers printed on the front plate just below the display, identify the individual digits that are displayed for some of the settings, i.e. function links, relay masks etc.

3.3 Menu system

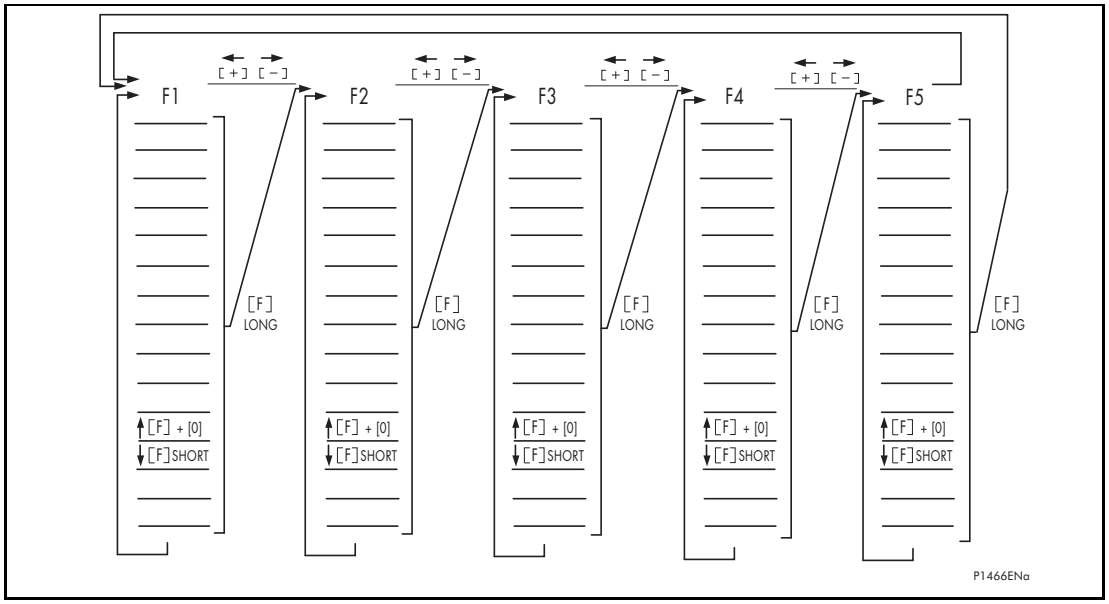


Figure 2: Menu format

Settings, measured values, alarm records and system data resides in a table known as MENU TABLE. Data within the relays is accessed via a MENU table. All the data displayed on the LCD or transmitted via the serial communications port is obtained via this table.

The table is comprised of cells arranged in rows and columns, like a spreadsheet. A cell may contain text, values, settings or functions. The first cell in a column, the column heading, contains text identifying the data grouped under it in that column.

3.3.1 Default display

The selected default display that appears on power-up can be selected by the user. Whilst the default display is visible it is possible to scroll through the available options with a momentary press of the [0] key. The required default display can be selected via menu cells 0411 or 0611. Alternatively, pressing the [0] key for 1 second will select the currently visible option as the default.

Following the initiation of a tap change operation the display will change to show the time remaining before the next tap change is due. It will do this by temporarily changing to default display 6, alarm status/raise volts/lower volts and time remaining. This change will not occur if display 7 is selected, as this option already displays the time remaining. The display will revert to the original option when either the timer expires, or the system voltage returns to within the deadband. Certain default displays show textual information about fault conditions, this information will be cleared along with the associated LED display, when the [0] key is pressed and held for 1 second.

The default display can be returned to without waiting for the 15 minute delay to expire by moving to a column heading and pressing the [0] key for 1 second.

3.3.2 Accessing the menu

Four keys on the front plate of the relay allow the menu to be scanned and the contents displayed on the liquid crystal display.

To move from the default display the [F] key should be pressed momentarily and the display will change to [0000 SYSTEM DATA], the column heading for the first menu column. Further momentary presses of the [F] key will step down the column, row by row, so that data may be read. If at any time the [F] key is pressed and held for one second the cursor will be moved to the top of the next column and the heading for that column will be displayed. Further momentary presses of the [F] key will then move down the new column, row by row. In this way the full menu of the relay may be scanned with just one key and this key is accessible with the cover in place on the relay. Pressing the [F] and [0] keys together can step back up the column.

The only settings which can be changed with the cover in place are those that can be reset either to zero or some preset value by means of the [0] key, provided they do not require a password to be entered.

To change any other settings the cover must be removed from the relay to gain access to the [+] and [–] keys that are used to increment or decrement a value. When a column heading is displayed the [–] key will change the display to the next column and the [+] key will change the display to the previous column, giving a faster selection.

When a cell that can be changed is displayed, the action of pressing either the [+] or [–] keys will put the relay in setting mode indicated by a flashing cursor in the display. To escape from the setting mode without making any change, the [0] key should be depressed for one second. Chapter 3.4 gives instructions for changing the various types of settings.

Password protection is provided for the configuration settings of the relay because an accidental change could seriously affect the ability of the relay to perform its intended functions. Configuration settings include the selection of CT and VT ratios, function link settings, opto-input and relay output allocation. Some control, logic and reset functions, are protected from change when the relay cover is in place.

3.3.3 Menu contents

Related data and settings are grouped in separate columns of the menu. Each column has a text heading (in capital letters) that identifies the data contained in that column. Each cell may contain text, values, settings and/or a function. The cells are referenced by the column number/row number. For example 0201 is column 02, row 01. When a cell is displayed the four digits at the top left hand corner of the LCD indicate the column number and row number in the menu table.

The full menu is given in the following tables, but not all the items listed will be available in a particular relay. Those cells that do not provide any useful purpose are not made available in the factory configuration. Certain settings will disappear from the menu when the user de-selects them; the alternative setting group is a typical example. If System Data Link (SD4) is set to ‘0’ alternative settings will be hidden and to make them visible, the System Data Link SD4 must be set to ‘1’.

3.3.4 Menu columns

Col No	Heading	Description
00	SYSTEM DATA	Settings and data for the system – relay and serial communications.
01	STATUS	Settings for tap control modes
02	MEASURE	Display of directly measured and calculated quantities
03	CONTROL 1	Settings for group 1 miscellaneous control functions
04	LOGIC 1	Settings for group 1 miscellaneous logic functions
05	CONTROL 2	Settings for group 2 miscellaneous control functions
06	LOGIC 2	Settings for group 2 miscellaneous logic functions
07	INPUT MASKS	User assigned allocation of logic input
08	RELAY MASKS	User assigned allocation of output relays

The menu cells that are read only are marked [READ]

Cells that can be set are marked [SET]

Cells that can be reset are marked [RESET]

Cells that are password protected are marked [PWP]

3.3.5 System data

Cell	Text	Status	Description
0000	SYSTEM DATA	READ	Column heading
0002	Password	PWP	Password that must be entered before certain settings may be changed
0003	SD Links	PWP	Function links that enable the user to enable (activate) the options required
0			
1	Rem Cntrl		1= enable remote control
2	Rem LSB		1= enable remote load shedding/boosting
3	Rem Grp2		1= enable remote change to group 2 setting
4	En Grp2		1= enable group two settings; 0 = hidden
5	1=Grp2		1= select group 2 settings
6	Irev=Grp 2		1= enable reverse current select group 2 settings
7	Log Evts		1= enable logic changes in event records
8			
9	Extrn V		1= TPI uses external V ref; 0=TPI uses system voltage
0004	Description	PWP	Product description – user programmable text
0005	Plant Ref.	PWP	Plant reference – user programmable text
0006	Model	READ	Model number that defines the product
0008	Serial No.	READ	Serial number – unique number identifying the particular product
0009	Freq	SET	Default sampling frequency - must be set to power system frequency
000A	Comms Level	READ	Indicates the Courier communication level supported by the product

Cell	Text	Status	Description
000B	Rly Address	SET	Communication address (1 to 255)
000C	Plnt Status	READ	Binary word, used to transport plant status information over communication network
000D	Ctrl Status	READ	Binary word used to indicate the status of control data
000E	Grp now	READ	Indicates the active setting group
000F	LSB Stage	READ	Indicates the last received load shedding command
0011	Software	READ	Software reference for the product
0020	Log Status	READ	Indicates the current status of all the logic inputs
0021	Rly Status	READ	Indicates the current status of the output relay drives
0022	Alarms	READ	Indicates the current state of internal alarms
0	Uncfg	READ	Error in factory configuration settings
1	Uncalib	READ	Operating in uncalibrated state
2	Setting	READ	Error detected in stored settings
3	No Service	READ	Out-of-service and not functioning
4	No Samples	READ	No A/D samples but still in service
5	No Fourier	READ	Fourier is not being performed
6	Test Wdog	SET	Test watchdog by setting this bit to “1”; 0 = normal

0002 SYS Password [PWP]

The selected configuration of the relay is locked under this password and cannot be changed until it has been entered. Provision has been made for the user to change the password, which may consist of four upper case letters in any combination. In the event of the password becoming lost a recovery password can be obtained on request, but the request must be accompanied by a note of the model and serial number of the relay.

0003 SYS Function Links [PWP]

These function links enable selection to be made from the system options.

0004 SYS Description [PWP]

This is text that describes the relay type. It is password protected and can be changed by the user to a name which may describe the scheme configuration of the relay if the relay is changed from the factory configuration.

0005 SYS Plant Reference [PWP]

The plant reference can be entered by the user, but is limited to 16 characters. This reference is used to identify the primary plant with which the relay is associated.

0006 SYS Model Number [READ]

The model number that is entered during manufacture has encoded into it the mechanical assembly, ratings and configuration of the relay. It is printed on the frontplate and should be quoted in any correspondence concerning the product.

0008 SYS Serial Number [READ]

The serial number is the relay identity and encodes also the year of manufacture. It cannot be changed from the menu.

0009 SYS Frequency [SET]

The set frequency from which the relay starts tracking on power-up.

000A Communication Level [READ]

This cell will contain the communication level that the relay will support. It is used by master station programs to decide what type of commands to send to the relay.

000B SYS Relay Address [SET]

An address between 1 and 254 that identifies the relay when interconnected by a communication bus. These addresses may be shared between several communication buses and therefore not all these addresses will necessarily be available on the bus to which the relay is connected. The address can be manually set. Address 0 is reserved for the automatic address allocation feature and 255 is reserved for global messages. The factory set address is 255.

000C SYS Plant Status [READ]

Plant status is a 16 bit word which is used to transport plant status information over the communication network. The various bit pairs are pre-allocated to specific items of plant.

000D SYS Control Status [READ]

The control status act like software contacts to transfer data from the relay to the master station controlling communications.

000E SYS Setting Group [READ]

Where a relay has alternative groups of settings which can be selected, then this cell indicates the current group being used by the relay. For KVGC202 it is either (Group 1) or (Group 2).

000F SYS LSB Stage [READ]

Cell 000F displays the level of load shedding/boosting at all times. The load shedding/boosting can be initiated either by energising opto inputs or via K-Bus. The opto inputs will override the commands over the serial port. The level of load shedding/boosting are displayed in this cell.

<Level 0> = “None” – All stages reset

<Level 1> = “Vred1” – Level 1 setting selected

<Level 2> = “Vred2” – Level 2 setting selected

<Level 3> = “Vred3” – Level 3 setting selected

When the auxiliary supply to the relay is interrupted the states of the load shedding/boosting is remembered. This ensures that the level of load shedding/boosting is not caused to change by interruptions of the auxiliary supply.

0020 SYS Logic Status

This cell indicates the current state of opto-isolated logic control inputs.

0021 SYS Relay Status

This cell indicates the current state of the output relay drives.

0022 Alarms

Indicates current state of internal alarms.

3.3.6 Status

Cell	Text	Status	Description
0100	STATUS		Column heading
0101	Control	READ	1 = Remote ; 2 = Local
0102	Mode	SET	1 = Manual ; 2 = Auto
0103	Tap	SET	No Operation ; Raise V ; Lower V
0104	ST Links		
	0 = Blocked	READ	1 = Tap change operation blocked
	1 =V<< blk		1 = Under voltage blocking
	2 = V<blkLower		1 = Under voltage detection
	3 = V>blkRaise		1 = Over voltage detection
	4 = TapFail		1 = Voltage remains outside deadband
	5 = I_C>		1 = Excessive circulating current
	6 = I_L>		1 = Line overcurrent detection
	7 = TotalOps>		1 = Tap change operations exceed thresh
	8 = FreqOps		1 = Frequent tap change operations
	9 = I Rev		1 = Reverse current blocking
	A = Run-Away		1 = Invalid tap change operation
	B = TapLimit		1 = Tap position above/below threshold
	C = I_L<		1= Line undercurrent detection
0105	Blocked	READ	1 = Tap change operation blocked
0106	V<< blk	READ	1 = Under voltage blocking
0107	V<blkLower	READ	1 = Under voltage detection
0108	V>blkRaise	READ	1 = Over voltage detection
0109	TpFail	READ	1 = Voltage remains outside deadband
010A	I_C>	READ	1 = Excessive circulating current
010B	I_L>	READ	1 = Line overcurrent detection
010C	TotalOps>	READ	1 = Tap change operations exceed thresh
010D	FreqOps	READ	1 = Frequent tap change operations
010E	I rev	READ	1 = Reverse current blocking
010F	Run-Away	READ	1 = Invalid tap change operation
0110	TapLimit	READ	1 = Tap position above/below threshold
0111	I_L<	READ	1= Line undercurrent detection

3.3.7 Measure

Cell	Text	Status	Description
0200	MEASURE	READ	Column heading
0201	Vph-Vph	READ	Measured line voltage
0202	Vreg	READ	Regulated voltage = Vbc – Vr – Vx – Vc
0203	I_C	READ	Circulating current

Cell	Text	Status	Description
0204	I_L	READ	Load current
0205	Power Fact	READ	Calculated from Ia/–90° with respect to Vbc
0206	Frequency	READ	Measured frequency
0207	TapPosition	READ	Actual tap position
0208	Highest tap	RESET	Highest tap used since last reset
0209	Lowest tap	RESET	Lowest tap used since last reset
020A	Total Ops	RESET	Total number of operations
020B	Freq Ops	RESET	Total number of frequent operations
020C	tREMAIN	READ	Time remaining to change next tap

3.3.8 Control 1

Cell	Text	Status	Description
0300	CONTROL 1	READ	
0301	CTL Links	PWP	Software links that are used to select the available optional group 1control functions.
0			
1	1= tINV		1 = Inverse time delay = dV.DT/(V ±Vs)
0302	CT Ratio	PWP	Line Current Transformer overall ratio
0303	VT Ratio	PWP	Line Voltage Transformer overall ratio
0304	I_n	PWP	Rated current winding of relay (1A or 5A)
0305	Vs	SET	Set value of remote regulated voltage
0306	dV	SET	Dead band = ±dV
0307	Vc(volt/I_n)	SET	Circulating current compensation
0308	Vr(volts/I_n)	SET	Resistive LDC compensation
0309	Vx(volts/I_n)	SET	Reactive LDC compensation (– = reverse)
030A	pf Angle	SET	Low power factor LDC compensation (90°)
030B	tINIT DT	SET	Initial definite time delay
030C	tINTER	SET	Inter tap delay
030D	tPULSE	SET	Tap pulse duration
030E	Level 1	SET	Load shedding/boosting level 1
030F	Level 2	SET	Load shedding/boosting level 2
0310	Level 3	SET	Load shedding/boosting level 3
0311	tTapChange	SET	Time between tap position indications

3.3.9 Logic 1

Cell	Text	Status	Description
0400	LOGIC 1	READ	Column heading
0401	LOG Links	PWP	Software links that are used to select the available optional group 1 blocking functions

Cell	Text	Status	Description
1	TpFail		1 = block outside dead band for maximum time
2	Ic> blk		1 = block for excessive circulating current
3	IL> blk		1 = block for excessive load current
4	Total opsBlk		1 = block for excessive number of operations
5	Freq opsBlk		1 = block for frequent operation
6	Irev blk		1 = block operation for reverse current flow
7	Runaway blk		1 = block for tap change runaway
8	IL<BLK		1= block for insufficient current
0402	V<<	SET	Under voltage total inhibit level (% of Vs)
0403	V<	SET	Over voltage blocking limit
0404	V>	SET	Under voltage blocking limit
0405	t V< V>	SET	Under/over voltage blocking timer
0406	tFAIL>	SET	Total time outside dead band to=failure
0407	Ic>	SET	Excessive circulating current threshold
0408	tIC	SET	Excessive circulating current time delay
0409	IL>	SET	Line overcurrent threshold
040A	IL<	SET	Line undercurrent threshold
040B	TpAvail	SET	Total number of taps available
040C	TP>	SET	Upper tap alarm limit
040D	TP<	SET	Lower tap alarm limit
040E	total ops>	SET	Total number of tap change operations
040F	ops/tP>	SET	Number of tap changes allowed in time tP
0410	tP	SET	Time period tP
0411	Display	SET	Default display required
0412	tTest Relay	SET	Relay test hold timer

3.3.10 Control 2

Cell	Text	Status	Description
0500	CONTROL (2)	READ	Software links that are used to select the available optional group 2 control functions.
0501	CTL Links	PWP	Function links
0			
1	1= tINV		1 = Inverse time delay = dV.DT/(V ±Vs)
0502	CT Ratio	PWP	Line Current Transformer overall ratio
0503	VT Ratio	PWP	Line Voltage Transformer overall ratio
0504	In	PWP	Rated current winding of relay (1A or 5A)
0505	Vs	SET	Set value of remote regulated voltage
0506	DV	SET	Dead band = ±dV
0507	Vc(volt/In)	SET	Circulating current compensation

Cell	Text	Status	Description
0508	Vr(volts/In)	SET	Resistive LDC compensation
0509	Vx(volts/In)	SET	Reactive LDC compensation (– = reverse)
050A	pf Angle	SET	Low power factor LDC compensation (90°)
050B	tINIT DT	SET	Initial definite time delay
050C	tINTER	SET	Inter tap delay
050D	tPULSE	SET	Tap pulse duration
050E	Level 1	SET	Load shedding/boosting level 1
050F	Level 2	SET	Load shedding/boosting level 2
0510	Level 3	SET	Load shedding/boosting level 3
0511	tTapChange	SET	Time between tap position indications

3.3.11 Logic 2

Cell	Text	Status	Description
0600	LOGIC 2	READ	Column heading
0601	LOG Links	PWP	Software links that are used to select the available optional group 2 blocking functions
1	TpFail		1 = block outside dead band for maximum time
2	Ic> blk		1 = block for excessive circulating current
3	IL> blk		1 = block for excessive load current
4	Total opsBlk		1 = block for excessive number of operations
5	Freq opsBlk		1 = block for frequent operation
6	Irev BLK		1 = block operation for reverse current flow
7	Runaway blk		1 = block for tap change runaway
8	IL<BLK		1= block for insufficient current
0602	V<<	SET	Under voltage total inhibit level (% of Vs)
0603	V<	SET	Over voltage blocking limit
0604	V>	SET	Under voltage blocking limit
0605	t V< V>	SET	Under/over voltage blocking timer
0606	tFAIL>	SET	Total time outside dead band to = failure
0607	Ic>	SET	Excessive circulating current threshold
0608	tIC	SET	Excessive circulating current time delay
0609	IL>	SET	Line overcurrent threshold
060A	IL<	SET	Line undercurrent threshold
060B	TpAvail	SET	Total number of taps available
060C	TP>	SET	Upper tap alarm limit
060D	TP<	SET	Lower tap alarm limit
060E	total ops>	SET	total number of tap change operations
060F	ops/tP>	SET	Number of tap changes allowed in time tP
0610	tP	SET	Time period tP
0611	Default Display	SET	Default display required (Multi Data / Time Remain / Vreg TapPos / IL IC / Operating Mode / Plant Ref / Description / Manufacturer)
0612	tTest Relay	SET	Relay test hold timer

3.3.12 Input masks

Cell	Text	Status	Description
0700	INPUT MASKS	READ	Column heading
0701	Remote	PWP	Logic input for remote selection of Auto/Manual mode
0702	Automatic	PWP	Logic input to select automatic mode
0703	Manual	PWP	Logic input to select manual mode
0704	Raise V	PWP	Logic input to manually initiate signal to raise the tap changer
0705	Lower V	PWP	Logic input to manually initiate signal to lower the tap changer
0706	Block	PWP	Logic input to block tap change operation (raise and lower)
0707	Level 1	PWP	Logic input for load shedding/boosting level 1
0708	Level 2	PWP	Logic input for load shedding/boosting level 2
0709	Level 3	PWP	Logic input load shedding/boosting level 3
070A	Stg Grp2	PWP	Logic input to select group 2 settings from external input

3.3.13 Relay masks

Cell	Text	Status	Description
0800	RELAY MASKS	READ	Column heading
0801	Raise V	PWP	Indication for raise volts tap change block
0802	Lower V	PWP	Indication for lower voltage tap change block
0803	Blocked	PWP	Indication if both raise and lower tap change operations are inhibited
0804	UnBlocked	PWP	Indication if tap change operations are not inhibited
0805	V<<	PWP	Alarm indication for under voltage blocking
0806	V<	PWP	Alarm indication for under voltage detection
0807	V>	PWP	Alarm indication for over voltage detection
0808	Tap Fail	PWP	Alarm indication for tap changer failure
0809	$I_{c>}$	PWP	Alarm indication for excessive circulating current detector
080A	$I_{L>}$	PWP	Alarm indication for overcurrent detector
080B	$I_{L<}$	PWP	Alarm indication for undercurrent detector
080C	TotalOps>	PWP	Alarm indication for tap change operations exceed a preset value
080D	FreqOps	PWP	Alarm indication for tap change operations exceed threshold over preset time period
080E	I_{rev}	PWP	Alarm indication for reverse current condition
080F	RUN-AWAY	PWP	Alarm indication for invalid tap change operation
0810	Tap Limit	PWP	Alarm indication for tap position indicator outside the set threshold settings
0811	Tap Odd	PWP	Current tap position is odd
0812	Tap Even	PWP	Current tap position is even
0813	Auto Mode	PWP	Relay is in ‘Automatic’ mode

Cell	Text	Status	Description
0814	Manual Mode	PWP	Relay is in 'Manual' mode
0815	Select tst rlys	PWP	Select relays to operate when relay test is selected
0816	Test Relays = [0]	PWP	Press [0] key to close relays selected

3.4 Changing text and settings

Settings and text in certain cells of the menu can be changed via the user interface. To do this the cover must be removed from the front of the relay so that the [+] and [–] keys can be accessed.

3.4.1 Quick guide to menu controls

Quick Guide to Menu Control with the Four Keys		
Current display	Key press	Effect of action
Default display	[0] long	Back-light turns ON – Reset condition monitor
		Select current display as default
	[0] short	Steps through the available default displays
	[F]	↓ Steps down to column heading SYSTEM DATA.
	[+]	Back-light turns ON – Reset condition monitor
	[–]	Back-light turns ON – Select current display as default
Column heading	[0]short	Back-light turns ON - no other effect.
	[0]long	Re-establishes password protection immediately and returns the default display.
	[F]long	→ Move to next column heading
	[F]short	↓ Steps down the menu to the first item in the column.
	[–]	→ Move to next column heading
	[+]	← Move to previous column heading
Any menu cell	[F]short	↓ Steps down the menu to the next item in the column.
	[F]long	↓ Displays the heading for the next column.
	[F]+[0]long	↑ Steps back up the menu to the previous item.
	[0]short	Back-light turns ON – no other effect.
	[0]long	Resets the value if the cell is resettable.
Any settable cell	[+] or [–]	Puts the relay in setting mode. The password must first be entered for protected cells.
Setting mode	[0]	Escapes from the setting mode without a setting change.
	[+]	Increments value – with increasing rapidity if held.
	[–]	Decrements value – with increasing rapidity if held.
	[F]	*Changes to the confirmation display.*
		If function links, text, relay or input masks are displayed the [F] key will step through them from left to right and finally change to the confirmation display.

Quick Guide to Menu Control with the Four Keys		
Current display	Key press	Effect of action
Confirmation mode	[+]	*Confirms setting and enters new setting or text.*
	[–]	*Returns prospective change to check/modify.*
	[0]	*Escapes from the setting mode without change.*

The actions shown in italic text can only be performed when the cover is removed.

[F]long – means press F key and hold for longer than 1 second.

[F]short – means press F key and hold for less than 1 second.

[F] – means press the F key length of time does not change the response.

[0]long – on perform a reset function when a resettable cell is displayed.

3.4.2 To enter setting mode

Give the [F] key a momentary press to change from the selected default display and switch on the back-light; the heading SYSTEM DATA will be displayed. Use the [+] and [–] keys, or a long press of the [F] key, to select the column containing the setting, or text that is to be changed. Then with the [F] key step down the column until the contents of that cell are displayed. Press either the [+] or [–] key to put the relay into the setting mode. Setting mode will be indicated by a flashing cursor on the bottom line of the display. If the cell is read-only, or password protected, then the cursor will not appear and the relay will not be in the setting mode.

3.4.3 To escape from the setting mode

IMPORTANT! If at any time you wish to escape from the setting mode without making a change to the contents of the selected cell: Hold the [0] key depressed for one second, the original setting will be returned and the relay will exit the setting mode.

3.4.4 To accept the new setting

Press the [F] key until the confirmation display appears:

Are You Sure?

+ = YES – = NO

1. Press the [0] key if you decide not to make any change.
2. Press the [–] key if you want to further modify the data before entry.
3. Press the [+] to accept the change. This will terminate the setting mode.

3.4.5 Password protection

Password protection is provided for the configuration settings of the relay. This includes CT and VT ratios, function links, input masks and relay masks. Any accidental change to configuration could seriously affect the ability of the relay to perform its intended functions, whereas, a setting error may only cause a grading problem. Individual settings are protected from change when the relay cover is in place by preventing direct access to the [+] and [–] keys.

The passwords are four characters that may contain any upper case letter from the alphabet. The password is initially set in the factory to AAAA, but it can be changed by the user to another combination if necessary. If the password is lost or forgotten access to the relay will be denied. However, if the manufacturer, or their agent is supplied with the serial number of the relay a back-up password can be supplied that is unique to that particular product.

3.4.6 Entering passwords

Using the [F] key, select the password cell [0002] in the SYSTEM DATA column of the menu. The word “Password” is displayed and four stars. Press the [+] key and the cursor will appear under the left hand star. Now use the [+] key to step through the alphabet until the required letter is displayed. The display will increment faster if the key is held down and the [–] key can be used in a similar way to move backwards through the alphabet. When the desired character has been set the [F] key can be given a momentary press to move the cursor to the position for the next character. The process is then be repeated to enter the remaining characters that make up the password. When the fourth character is acknowledged by a momentary press of the [F] key the display will read:

Are You Sure?

+ = YES – = NO

1. Press the [0] key if you decide not to enter the password.
2. Press the [–] key if you want to modify the your entry.
3. Press the [+] to enter the password. The display will then show four stars and if the password was accepted the alarm LED will flash. If the alarm LED is not flashing the password was not accepted, a further attempt can be made to enter it, or the [F] key pressed to move to the next cell.

   Note: When the password cell is displayed, do not press the [+] or [–] key whilst the alarm LED is flashing unless you want to change the password.

3.4.7 Changing passwords

When the password has been entered and the alarm LED is flashing either the [+] or [–] key is pressed to put the relay in setting mode. A new password can now be entered as described in Chapter 3.4.6. After entering the fourth character make a note of the new password shown on the display before pressing the [F] key to obtain the confirmation display.

Are You Sure?

+ = YES – = NO

1. Press the [0] key if you decide not to enter the new password.
2. Press the [–] key if you want to modify the your entry.
3. Press the [+] to enter the new password which will then replace the old one.

Note: Make sure the new password has been written down before it is entered and that the password being entered agrees with the written copy before accepting it. If the new password is not entered correctly you may be denied access in the future. If the password is lost a unique back-up password for that relay can be provided from the factory, or certain agents, if the serial number of the product is quoted.

3.4.8 Restoration of password protection

Password protection is reinstated when the alarm LED stops flashing, this will occur fifteen minutes after the last key press. To restore the password protection without waiting for the fifteen minute time-out, select the password cell and hold the reset key [0] depressed for one second. The alarm LED will cease to flash to indicate the password protection is restored. Password protection is also restored when the default display is selected (see Chapter 3.3.1).

3.4.9 Entering text

Enter the setting mode as described in Chapter 3.4.2 and move the cursor with the [F] key to where the text is to be entered or changed. Then using the [+] and [–] keys, select the character to be displayed. The [F] key may then be used to move the cursor to the position of the next character and so on. Follow the instructions in Chapter 3.4.3 to exit from the setting change.

3.4.10 Changing function links

Select the page heading required and step down to the function links “SD Links”, “Function Links”, or LOG Links” and press either the [+] or [–] to put the relay in a setting change mode. A cursor will flash on the bottom line at the extreme left position. This is link “F”; as indicated by the character printed on the front plate under the display.

Press the [F] key to step along the row of links, one link at a time, until some text appears on the top line that describes the function of a link. The [+] key will change the link to a “1” to select the function and the [–] key will change it to a “0” to deselect it. Follow the instructions in Chapter 3.4.3 to exit from the setting change.

Not all links can be set, some being factory selected and locked. The links that are locked in this way are usually those for functions that are not supported by a particular relay, when they will be set to “0”. Merely moving the cursor past a link position does not change it in any way.

3.4.11 Changing setting values

Move through the menu until the cell that is to be edited is displayed. Press the [+] or [–] key to put the relay into the setting change mode. A cursor will flash in the extreme left hand position on the bottom line of the display to indicate that the relay is ready to have the setting changed. The value will be incremented in single steps by each momentary press of the [+] key, or if the [+] key is held down the value will be incremented with increasing rapidity until the key is released. Similarly, the [–] key can be used to decrement the value. Follow the instructions in Chapter 3.4.3 to exit from the setting change.

Note: When entering CT RATIO or VT RATIO the overall ratio should be entered, i.e. 2000/5A CT has an overall ratio of 400:1. With rated current applied the relay will display 5A when CT RATIO has the default value of 1:1 and when the ratio is set to 400:1 the displayed value will be 400 x 5 = 2000A.

3.4.12 Setting communication address

The communication address will be set to 255, the global address to all relays on the network, when the relay is first supplied. Reply messages are not issued from any relay for a global command, because they would all respond at the same time and result in contention on the bus. Setting the address to 255 will ensure that when first connected to the network they will not interfere with communications on existing installations. The

communication address can be manually set by selecting the appropriate cell for the SYSTEM DATA column, entering the setting mode as described in Chapter 3.4.2 and then decrementing or incrementing the address. Then exit setting mode as described in Chapter 3.4.3.

There is a feature in Courier that can be used to automatically allocate an address to the relay, provided the master station software supports this feature. It is recommended that the user enters a name for the plant reference in the appropriate menu cell and then sets the address manually to “0”. If auto addressing has been selected in the master station software, the master station will then detect that a new relay has been added to the network and automatically allocate the next available address on the bus to which that relay is connected and communications will then be fully established.

3.4.13 Setting input masks

An eight bit mask is allocated to each control function that can be influenced by an external input applied to one or more of the logic inputs. When the menu cell for an input mask is selected the top line of the display shows text describing the function to be controlled by the inputs selected in the mask. A series of “1”s and “0”s on the bottom line of the display indicate which logic inputs are selected to exert control. The numbers printed on the front plate under the display indicate each of the logic inputs (L7 to L0) being displayed. A “1” indicates that a particular input is assigned to the displayed control function and a “0” indicates that it is not. The same input may be used to control more than one function.

3.4.14 Setting output masks

An eight bit mask is allocated to each control function. When a mask is selected the text on the top line of the display indicates the associated function and the bottom line of the display shows a series of “1”s and “0”s for the selected mask. The numbers printed on the front plate under the display indicate the output relay (RLY7 to RLY0) that each bit is associated. A “1” indicates that the relay will respond to the displayed function and a “0” indicates that it will not.

A logical “OR” function is performed on the relay masks so that more than one relay may be allocated to more than one function. An output mask may be set to operate the same relay as another mask so that, for example, one output relay may be arranged to operate for all the functions required to block tap operations and another for only those functions that are to initiate tap change.

3.4.15 Resetting values

The values of highest tap, lowest tap, total number of operations and total number of frequent operations can be reset to zero. To achieve the menu cell containing the values to be reset (measure column) must be displayed and then the [0] key held depressed for at least one second to effect the reset.

3.4.16 Resetting CONTROL LED indication

If the tap change operation is blocked the “CONTROL’ LED is lit permanently and the textual information for the condition is displayed via the correct default display. If any of the following conditions are detected, the ‘CONTROL’ LED will flash and the textual information for the condition is displayed via the correct default display:

- Tap change failure [Tfail]
- Number of tap change operations[TotalOps]
- Frequent tap change operations [FreqOps]
- Run Away Protection [RunAway]

The ‘CONTROL’ LED can be reset only after these conditions are cleared by depressing the [0] key for 1 second.

The only other time the ‘CONTROL’ LED is lit permanently is when the inter-tap delay is set to zero for continuous tap change operation.

3.5 External connections

Standard connection table

Function	Terminal				Function
Earth Terminal	–	1	2	–	Not used
Watchdog Relay	b	3	4	m	Watchdog Relay
(Break contact)		5	6		(Make contact)
48V Field Voltage	[+]	7	8	[–]	48V Field Voltage
Not used	–	9	10	–	Not used
Not used	–	11	12	–	Not used
Auxiliary Supply (+dc or ac)	(+)	13	14	(–)	Auxiliary Supply (–dc or ac)
External TPI	In	15	16	In	External TPI
System Voltage	In	17	18	In	System Voltage Input (phase C)
Input (phase B)					
Tap position indication (phase B)	In	19	20	In	Tap position indication (phase C)
Pilot wire connection	–	21	22	–	Pilot wire connection
Circulating current (1A)	In	23	24	Out	Circulating current (1A)
Circulating current (5A)	In	25	26	Out	Circulating current (5A)
Load current	In	27	28	Out	Load current
Output Relay 4	–	29	30	–	Output Relay 0
		31	32		
Output Relay 5	–	33	34	–	Output Relay 1
		35	36		
Output Relay 6	–	37	38	–	Output Relay 2
		39	40		
Output Relay 7	–	41	42	–	Output Relay 3
		43	44		
Opto Control Input L3	(+)	45	46	(+)	Opto Control Input L0
Opto Control Input L4	(+)	47	48	(+)	Opto Control Input L1
Opto Control Input L5	(+)	49	50	(+)	Opto Control Input L2
Opto Control Input L6	(+)	51	52	(–)	Common L0/L1/L2
Opto Control Input L7	(+)	53	54	–	K-Bus Serial Port
Common L3/L4/L5/L6/L7	(–)	55	56	–	K-Bus Serial Port

Key to connection tables

[+] and [–] indicate the polarity of the dc output from these terminals.

(+) and (–) indicate the polarity for the applied dc supply.

In/Out the signal direction for forward operation.

Note: All relays have standard Midos terminal blocks to which connections can be made with either 4mm screws or 4.8mm pre-insulated snap-on connectors. Two connections can be made to each terminal.

3.5.1 Auxiliary supply

The auxiliary voltage may be dc or ac provided it is within the limiting voltages for the particular relay. The voltage range will be found on the front plate of the relay; it is marked (Vx = (24V - 125V) or (48V - 250V). An ideal supply to use for testing the relays will be 50V dc or 110V ac because these values fall within both of the auxiliary voltage ranges.

The supply should be connected to terminals 13 and 14 only. To avoid any confusion it is recommended that the polarity of any applied voltage is kept to the Midos standard:

- for dc supplies the positive lead connected to terminal 13 and the negative to terminal 14.
- for ac supplies the live lead is connected to terminal 13 and the neutral lead to terminal 14.

3.5.2 Logic control inputs

There are a number of logic control inputs to the relay that are optically coupled to provide galvanic isolation between the external and internal circuits. They are rated at 48V and the power supply within the relay provides an isolated field voltage to energise them. This arrangement keeps the power consumption of these inputs to a minimum and ensures that they always have a supply to energise them when the relay is operational.

Software filtering is applied to prevent induced ac signals in the external wiring causing operation of logic inputs. This is achieved by sampling the logic inputs eight times per cycle and five consecutive samples have to indicate that the input is energised in a positive sense before it is accepted. This ensures that the inputs are relatively immune to spurious operation from induced ac signals in the wiring. The capture time is:

- 12 ±2.5ms at 50Hz
- 10.4 ±2.1ms at 60Hz

Note: These inputs will not capture a fleeting contact unless it dwells in the closed state for a time exceeding the above values.

The opto-isolated logic control inputs are divided into two groups: three (L0, L1, L2) have their common connection on terminal 52 and inputs (L3, L4, L5, L6, L7) have their common connection on terminal 55. When they are to be energised from the field voltage then terminals 52 and 55 must be connected to terminal 8, the negative of the field voltage. The logic inputs can then be energised by connecting a volt free contact between the positive of the field voltage, terminal 7, and the terminal for the appropriate logic input.

The circuit for each opto-isolated input contains a blocking diode to protect it from any damage that may result from the application of voltage with incorrect polarity. Where the opto-isolated input of more than one relay is to be controlled by the same contact it will be necessary to connect terminal 7 of each relay together to form a common line. In the example circuit below, contact X operates L1 of relay 1 and contact Y operates L0 of relay 1 as well as L0 and L1 of relay 2. L2 is not used on either relay and has no connections made to it.

The logic inputs can be separated into two isolated groups when it is necessary to energise some from the station battery. The logic inputs are rated at 48V and it will be necessary to connect an external resistor in series with the input if the battery is of higher rated voltage. The value of this resistor should be 2000 ohms for every additional 10V.

The field voltage is not earthed and has insulation rated for 2kV for 1 minute. Thus if necessary the positive terminal of the field voltage could be connected to the positive terminal of the external battery. Also the two separate groups of logic inputs could be energised from separate batteries.

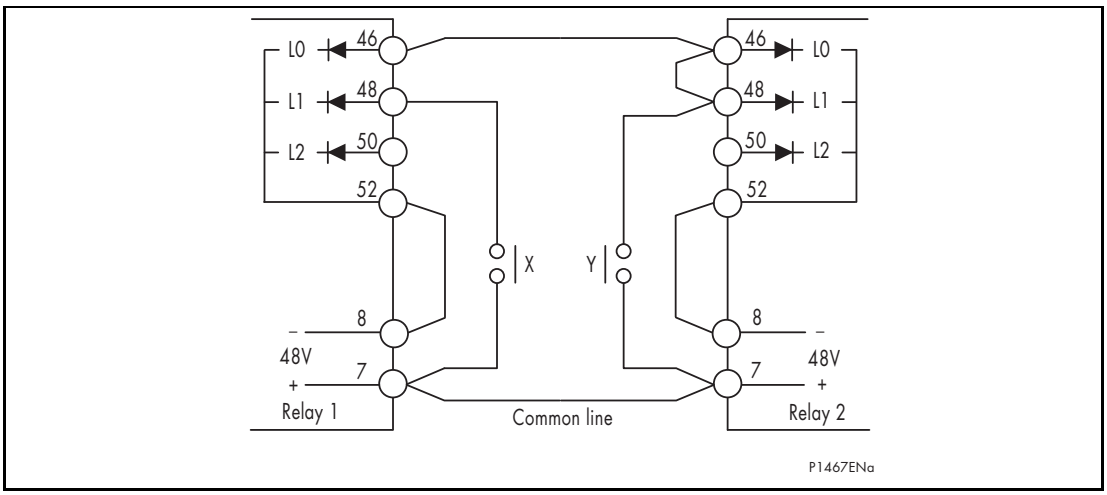


Figure 3: Example connection of logic inputs

3.5.3 Analogue inputs

The relay has six analogue inputs, two on the microprocessor board and four on the auxiliary expansion board. Each is fed via an input transducer, a low pass filter and a three range scaling amplifier. The analogue signals are sampled eight times per cycle on each channel as the sampling rate tracks the frequency of the input signal.

The wide setting range provided on the relay enables the relay to operate from either 1A or 5A current transformers. The following analogue channels are utilised:

Channel	Function	Relay Terminals
AN0	Load Current Input	27 and 28
AN1	Tap Position Indication	19 and 20
AN2	System Voltage Input - Low Accuracy	17 and 18
AN3	External TPI supply	15 and 16
AN4	Circulating Current Input	23 & 24 for 1A or 25 & 26 for 5A
AN6	System Voltage Input - High Accuracy	17 and 18

3.5.4 Output relays

Eight programmable output relays are provided on relays. They can be arranged to operate in response to any, or all, of the available functions by suitably setting the OUTPUT MASKS. The control functions to which these relays respond are selectable via the menu system of the relay.

In addition there is a watchdog relay which has one make and one break contact. Thus it can indicate both healthy and failed conditions. As these contacts are mainly used for alarm purposes, they have a lower rating than the programmable outputs. The terminal numbers for the output relay contacts are given in the table at the start of Chapter 3.5.

3.5.5 Setting the relay with a PC or Laptop

Connection to a personal computer (PC), or lap top, via an K-Bus/RS232 interface Type KITZ 101 or KITZ 102 will enable settings to be changed more easily. Alternatively a KITZ 201 may be incorporated into the scheme which enables a PC or lap top to be directly connected via the serial port mounted on the front plate. Software is available for the PC that allow on line setting changes in a more user friendly way, with a whole column of data being displayed instead of just single cells. Setting files can also be saved to floppy disc and downloaded to other relays of the same type. There are also programs available to enable settings files to be generated off-line, i.e. away from the relays that can be later down-loaded as necessary.

The communication connections and available software are covered in Chapter 7.

3.6 Alarm flags

A full list of the alarm flags will be found in Chapter 3.3.5 and they are located in cell 0022 of the SYSTEM DATA column of the menu. They consist of nine characters that may be either “1” or “0” to indicate the set and reset states respectively. The control keys perform for this menu cell in the same way as they do for Function Links. The cell is selected with the function key [F] and the relay then put in the setting mode by pressing the [+] key to display the cursor. The cursor will then be stepped through the alarm word from left to right with each press of the [F] key and text identifying the alarm bit selected will be displayed.

The only alarm flag that can be manually set is bit 6, the watchdog test flag. When this flag is set to “1” the watchdog relay will change state and the green LED will extinguish.

When any alarm flag is set the ALARM LED will be continuously lit. However, there is another form of alarm condition that will cause the ALARM LED to flash and this indicates that the password has been entered to allow access to change protected settings within the relay. This is not generally available as a remote alarm and it does not generate an alarm flag.

Note: No control will be possible via the key pad if the “Unconfigured” alarm is raised because the relay will be locked in a non-operative state.

4. APPLICATION OF CONTROL FUNCTIONS

The settings that customise the relay for a particular application are referred to as the configuration. They include the function links, input masks, relay masks, etc and they are password protected to prevent them being changed accidentally. Together these settings select the functions that are to be made available and how they are to be interconnected.

Before the advent of integrated numerical relays, protection and control schemes comprised individual relays that had to be interconnected and a diagram was produced to show these interconnections. The configuration of a numerical relay is the software equivalent of these interconnections. With the software approach, installations can be completed in much shorter times, especially for repeat schemes, saving valuable time and cost. A second advantage is the ability to make some changes without having to disturb the external wiring.

Before the connection diagrams can be drawn for an installation, it will be necessary to decide how the logic within the relay is to function. A copy of the logic diagram can be found at the back of this manual. It should be copied and the appropriate squares in the input and relays masks can be shaded in to show which logic inputs and output relays are to be assigned in each mask. The function links should then be drawn on the diagram in position “0” or “1” as required.

These software links may turn functions on, or off, and when in the “off” state unnecessary settings will not appear in the menu. On completion of the configuration diagrams the function link settings can then be read off the logic diagram and entered as a series of ones and zeroes, in the boxes provided on the logic diagram.

Case connection diagrams for the KVGC202 can be found at the back of this manual. They may be copied and notes added in the appropriate boxes to indicate the function of the logic inputs and relay outputs. This diagram will then give the appropriate terminal numbers to which the external wires must be connected. In particular, it will show the terminal numbers to which the current and voltage transformer connections are to be made.

The logic and case connection diagrams provide sufficient information to enable the full external wiring diagrams to be drawn and the operation of complete protection and control scheme to be understood.

4.1 Configuring the relay

Each scheme of protection and control will have its own particular configuration settings. These can be named appropriately and the name entered as the “description” in cell 0004 in the SYSTEM DATA column of the menu. If the scheme were likely to become a standard that is to be applied to several installations it would be worthwhile storing the configuration on a floppy disc so that it can be downloaded to other relays.

The configuration file can be made even more useful by adding appropriate general settings for the supervision and control functions. It will then only require the minimum of settings to be changed during commissioning and installation.

4.2 Changing the configuration of the relay

4.2.1 SYSTEM DATA (SD)

Select the SYSTEM DATA column of the menu; enter the password and then step down to the cell containing the SD links. Press the [+] key to put the relay into setting mode and use to [F] key to step through the options. The option will be shown in an abbreviated form on the top line of the display as each function link is selected. To select an option set the link to “1” with the [+] key and to deselect it set it to “0” with the [–] key.

The following options are available via links SD0 to SD7:

SD0	Not used	
SD1	Rem Cntrl	1 = enable remote control
SD2	Rem LSB	1 = enable load shedding/boost
SD3	Rem Grp2	1 = enable remote change to group2 settings
SD4	En Grp2	1 = enable group 2 settings
		0 = hide group 2 settings
SD5	1 = Grp2	1 = select group 2 settings
SD6	Irev = Grp2	1 = reverse current selects group 2
SD7	Log Evts	1 = enable storing of logic changes in event recorder
SD8	Not used	
SD9	Extrn V	1 = TPI uses external voltage VT

When the selection has been completed continue to press the [F] key until the confirmation display appears and confirm the selection.

Now step down the menu to cell [0004 Description] and enter a suitable name for the configuration; a maximum of sixteen characters are available.

Step down one cell [0005 Plant Ref.], where a suitable reference can be entered for the plant that the relay is to protect. If the configuration is for a relay that is to be applied to one particular circuit, then the reference by which the circuit is known can be entered at this time; a maximum of sixteen characters are available.

Now move down the SYSTEM DATA column to cell [0009 Freq] and set the frequency to 50Hz or 60Hz as appropriate. This is an important setting because it will be the default frequency used by the analogue/digital converter when appropriate signals are not available for frequency tracking.

If the address of the relay on the serial communication bus is known then it can be entered at this time. This cell is password protected on the series 2 relays.

This concludes the settings that can be entered in this menu column at this time.

4.2.2 Logic links (LOG)

The Logic Links under the LOGIC menu column heading customise the auxiliary functions of the relay. To modify these settings put the relay into setting mode by pressing the [+] key. Step through the function links with the [F] key and set the links for the options required.

LOG0	Not used	
LOG1	TpFail	1 = Block if outside dead time for max time
LOG2	I_C > Blk	1 = Block for excessive circulating current
LOG3	I_L > Blk	1 = Block for excessive load current
LOG4	total opsBlk	1 = Block for excessive number of operations
LOG5	Freq opsBlk	1 = Block for frequent operations
LOG6	I_{rev} Blk	1 = Block for reverse current
LOG7	Runaway Blk	1 = Block for tap change runaway
LOG8	I_{rev} – Grp 2	1 = Reverse current to select group 2
LOG9	Il<blk	1 = Block for insufficient current

When the selection has been completed continue to press the [F] key until the confirmation display appears and confirm the selection.

4.2.3 Control links (CTL)

The Control Links under the CONTROL menu column heading customise the auxiliary functions of the relay. Put the relay into setting mode by pressing the [+] key. Step through the function links with the [F] key and set the links for the options required.

CTL0 Not used

CTL1 tINV 1 = Inverse time delay for initial tap delay

When the selection has been completed continue to press the [F] key until the confirmation display appears and confirm the selection.

Default logic inputs

The function of the programmable logic inputs is selected in the INPUTS menu column. The following settings are not mandatory, but it is suggested that they are followed where possible so that different schemes will use a particular logic input for the same or similar function.

L0	Automatic	[Sets KVGC to automatic regulation of voltage]
L1	Manual	[Only manual tap changes], disables automatic control
L2	Raise V	[Raises the voltage by 1 tap in manual mode]
L3	Lower V	[Lowers the voltage by 1 tap in manual mode]
L4	Block	[Inhibits operation and resets timers]
L5	Level 1	[Sets load shedding/boost to level 1]
L6	Level 2	[Sets load shedding/boost to level 2]
L7	Level 3	[Sets load shedding/boost to level 3]

4.2.4 Default output relays

The function of the programmable relay outputs is selected in the RELAYS column. The following settings are not mandatory, but it is suggested that they are followed where possible so that different schemes will use a particular output relay for the same or similar function.

RLY0	Raise V	[Raises the voltage by 1 tap]
RLY1	Lower V	[Lowers the voltage by 1 tap]
RLY3	Blocked	[KVGC202 blocked from automatic operation]
RLY4	V<<	[Under voltage blocking]
RLY5	V<	[Low voltage supervision]
RLY6	V>	[Over voltage supervision]
RLY7	Ic>	[Excessive circulating current supervision]
RLY8	IL>	[Overcurrent supervision]

4.3 Setting group selection

The relay has two setting groups, but as supplied only setting group 1 will be visible. To make the second group of settings visible in the menu, set function link SD4=1 in the SYSTEM DATA column. The value of the group 2 settings is unimportant when link SD4 = 0, because group 1 settings will be in use by default.

The menu cell 000E, in the SYSTEM DATA column, is a read only cell that displays the setting group that is in operation.

The active setting group can be selected remotely or locally. Remote control is enabled by setting link SD3=1 and the active setting group can then be controlled by remote command over the serial communications connection. The active setting group is stored when the relay is powered down and restored on power up. Local control is enabled by setting SD3=0 and then using SD5 to select the desired group; SD5=0 – setting group 1, SD5=1 – setting group 2. If SD6=1 then reverse current will automatically select group 2 settings.

Note: If [SD4] = 0 then the group 2 settings will be hidden and group 1 will be active by default.

Link [SD4] must be set to "1" to make the second setting group active. Then manual selection of Group 2 can be made by setting link SD5=1 or a reverse current will select Group 2 if link SD6=1.

4.4 ApplicatIons

4.4.1 Introduction

As the loads connected to a distribution network vary through out the day, so the do the voltage drops in the conductors and transformers. If unchecked this would lead to unacceptable variations in voltages supplied to consumers. To prevent this the transformers in primary substations and above are generally fitted with on load tapchangers, usually on the HV side. These are motorised mechanical switching arrangements that adjust the transformer turns ratio, typically in steps of 1.25% or 1.43%, whilst the transformers are in use and carrying a load.

The operation of the tap changer mechanism is automatically controlled by a voltage regulating relay (VRR) such as the KVGC202. A VRR constantly monitors the system voltage and initiates the tap change mechanism to Raise or Lower the voltage to be within set limits of a desired value.

4.4.2 Basic requirements

The fundamental objective of a VRR is to control a voltage regulating transformer such that the system voltage is maintained within set limits of ± dVs%, about a reference voltage setting Vs.

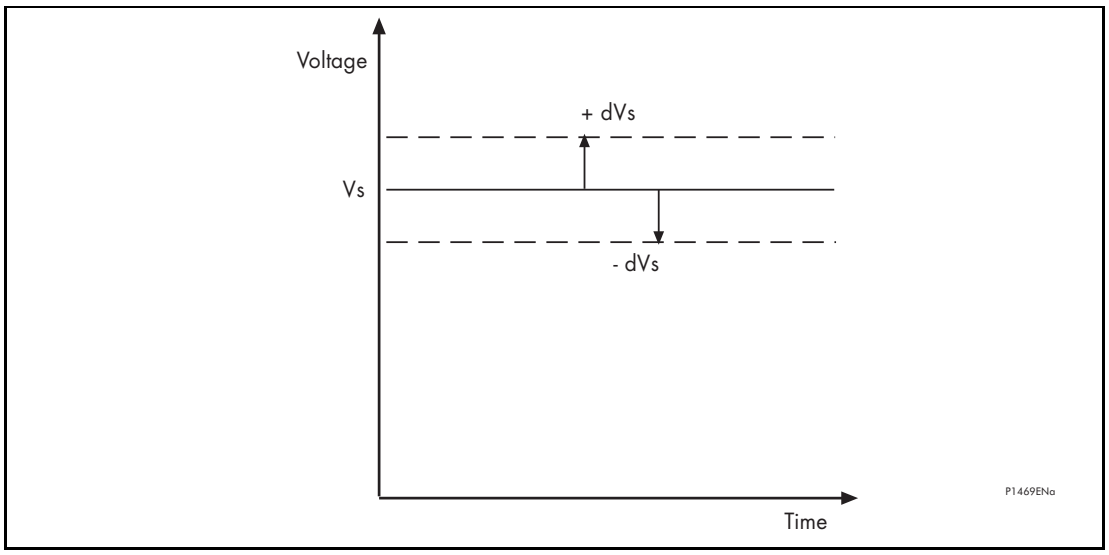


Figure 4:Basic Regulating Requirements

These limits define a deadband of ± dVs% of Vs which are dependent on the tap step increment of the regulating transformer. Typically, ± dVs% = ±1% for an average tap step increment of 1.43% on the transformer to prevent hunting.

The VRR compares the monitored system voltage with the reference voltage setting Vs and provides raise and lower signals to the tap changer to control the system voltage to be within the set deadband limits of ± dVs%.

4.4.3 Operating time delay

In a basic voltage regulating control relay it is necessary to incorporate a time delay to prevent tap changes due to momentary voltage fluctuations. A short time delay provides better regulation but results in excessive operation of the tap changer mechanism leading to increased maintenance and hence operating costs.

The relay incorporates an initial time delay before the initiation of a tap change sequence. On expiration of the time delay the appropriate 'Raise Volts' or 'Lower Volts' output relay operates to control the tap changer. The initial time delay is the time delay to initiate the first tap change step in a multiple sequence. Further tap change steps can then be initiated by a fixed delay setting defined as the 'Inter tap delay'.

4.4.3.1 Initial delay (tINIT)

The initial Delay timer is an integrating type and so it resets at a rate equal to the rate at which it times out. This ensures that a tap change sequence is initiated when the mean system voltage remains outside the deadband for the set initial delay. The timer resets instantaneously if the voltage is swung through the deadband setting from one side to the other.

4.4.3.2 Definite/Inverse time characteristics

The time delay to initiate a tap change sequence may have either a definite or inverse time characteristic selectable by control link CTL1. Selection of a 'Definite' initial time delay provides a fixed, definite time delay before initiating a tap change and is independent of the voltage deviation. Whereas, selection of an 'Inverse' characteristic gives the initial time delay as follows: -

The general expression for the inverse time curve is:

t = k + [(initial time delay setting) x (1/N)]

where:

k = 0.5 for initial time delay setting ≤20s

k = 0 for initial time delay setting >20s

N indicates deviation from Vs in multiples of dVs % and is calculated as:

$$N = \left(\frac{(Vreg - Vs)}{dVs}\right)$$

where :

Vreg = Voltage to be regulated

Vs = Voltage setting (90 to 139V in 0.1V steps)

dVs = Dead band (±0.5% to ±20% of Vs in 0.1% steps)

Indication of how long the tap delay timer has to run before the next tap change can be displayed on the LCD display.

An inverse characteristic reduces the response time of a tap changer to correct large voltage deviations thus reducing the risk of damage to consumer's equipment. For higher voltage systems and for transformers where large voltage deviations are envisaged, the inverse characteristic is preferred. The definite time delay is predominantly used on low voltage distribution transformers.

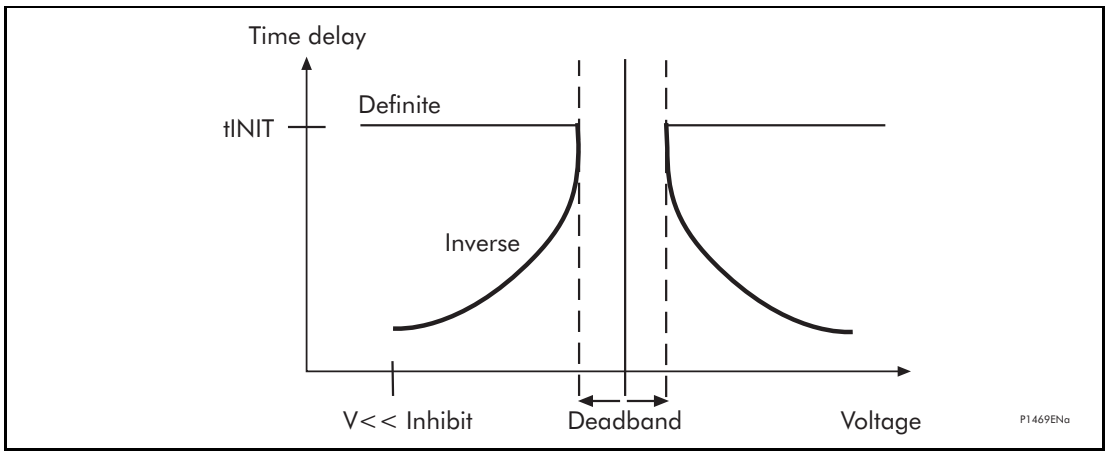


Figure 5: Inverse time or definite time delay prior to tap change initiation

4.4.3.3 Intertap Delay

If additional tap changes are required to bring the voltage back within the deadband limits a definite intertap delay determines the delay between subsequent tap change initiations. The inter-tap delay will start after the tap pulse duration has elapsed.

While the regulated voltage remains outside the deadband the output relay will continue to give pulsed closure for the tap pulse duration at intervals determined by the Intertap Delay. Reduction of the intertap time to 0 seconds will result in a continuous output indicated by a continuously illuminated red 'Control' LED.

4.4.3.4 Tap Pulse Duration (tPULSE)

The tap change initiating signal to 'Raise Volts' or 'Lower Volts' uses the same tap pulse duration in order to increment or decrement the tap position by one. The tap pulse duration is user selectable, 0.5-5s.

4.4.4 Operating Sequences

For a large voltage deviation outside the set deadband the tap changer is required to perform a multiple tap change sequence. Two main methods of controlling such a sequence are as follows:-

4.4.4.1 Method 1

This is the standard method and is suitable where rapid correction of large voltage deviations is required to give better regulation.

The initial delay setting (tINIT) determines the delay in initiating any tap change sequence. After the set initiating pulse (tPULSE) the inter-tap delay setting determines the delay between subsequent tap change initiations. This process continues until the system voltage is restored to within the deadband limits.

For rapid restoration of nominal voltage conditions the inter tap delay can be set equal to the operating time of the tap changer mechanism, the limitation being that the tap changer should be able to respond to an output from the VRR.

Although this method of operation provides better system voltage regulation, it may also result in excessive operation of the tap changer mechanism. An alternative method of operation is described below which can significantly increase the total time to restore nominal voltage whilst correcting larger voltage deviations more rapidly.

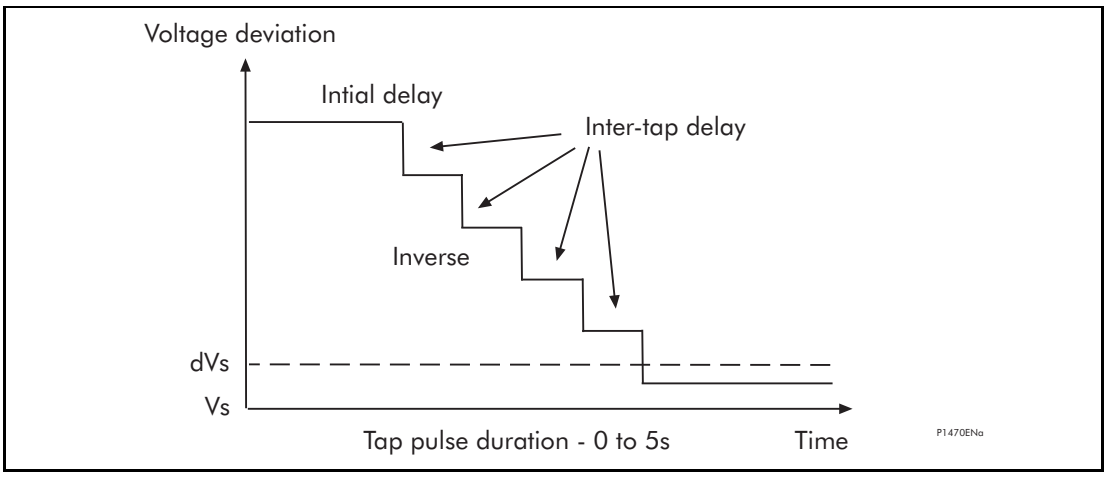


Figure 6: Initial and inter tap delay used for multiple tap change sequence

4.4.4.2 Method 2

For this method a normally open contact operated by the tap changer mechanism is connected to an opto assigned to BLOCK. This contact is closed whilst the mechanism is operating to block the relay. This resets the initial delay timer (tINIT) during each tap change step and hence the initial timer (tINIT) operates after completion of each tap change.

The normally open contact is usually operated by direct movement of the tap changer's motor mechanism using the directional sequence switch or an interposing auxiliary relay.

In older static designs of VRR a contact which opened during each tap change step was connected to isolate the measuring voltage to the VRR. The undervoltage inhibit was arranged to reset the initial time delay to achieve the initial time delay for each tap change. The KVGC202 can provide the same functionality whereby if the voltage falls below the V<< undervoltage detector setting it will operate and instantaneously reset the initial time delay thus inhibiting the relay outputs to 'Raise' or 'Lower' tap change operations.

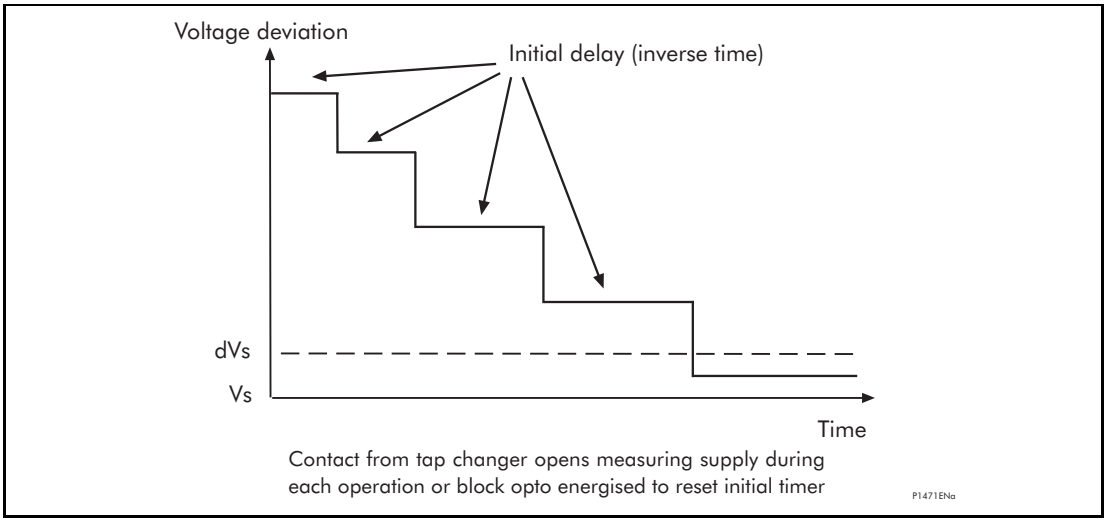

Voltage deviation
Initial delay (inverse time)
dVs
Vs
Time
Contact from tap changer opens measuring supply during each operation or block opto energised to reset initial timer
P1471ENa

Figure 7: Initial delay used for multiple tap change sequence

For inverse initial delays the time delay between tap changes gets progressively longer as the voltage deviation decreases. With definite initial delay settings the time delay between each tap change is the fixed initial delay setting.

Method 2 rapidly corrects large voltage deviations, but greatly extends the total time the voltage remains outside the deadband and is suitable only where load conditions will tolerate this.

4.5 Line drop compensation

Throughout a voltage distribution network it is often required to regulate the system voltage at a point remote to the regulating transformer, for example, the customer end of a feeder. The remote system voltage is to be regulated within the deadband limits irrespective of varying load current conditions. As such the regulating transformer is required to supply the regulated system voltage, plus the voltage drop across the feeder.

Due to varying power factor requirements it is necessary to consider both resistive and reactive components of the line drop voltage, separately. Line drop compensation (LDC) provides a voltage proportional to the line drop voltage derived from the line load current, which is vectorially summated with the measuring supply voltage so as to boost the voltage output from the regulating transformer to supply the line drop and remote regulated voltage, see Figure 8. Note, the voltage input and current input for LDC to the KVGC202 are quadrature (90°) connected i.e. IA (terminals 27-28) and VBC (terminals 17-18). Correct LDC can also be achieved with other quadrature connections IB and VCA or IC and VAB.

In the KVGC202 the resistive and reactive line drop voltage, Vr and Vxl are calculated as:

$$Vr = \frac{\sqrt{3} \times Ip \times RL}{VT\_ratio}$$

$$Vr = \frac{\sqrt{3} \times Ip \times XL}{VT\_ratio}$$

Where:

Ip = primary rated current of the line CT

RL = resistive component of line impedance

XL = reactive component of line impedance

As can be seen from the above equations the KVGC is set in terms of the resistive and reactive volt drop that will occur when rated current is applied to the relay. The relay then applies a level of compensation proportional to the level of current. For example, a setting of Vr = 20 V will produce a compensation voltage equal to 20 *Iload/Irated Volts. Figure 9 below shows a vector diagram demonstrating the effect of the separate resistive and reactive compensation applied to the relay.

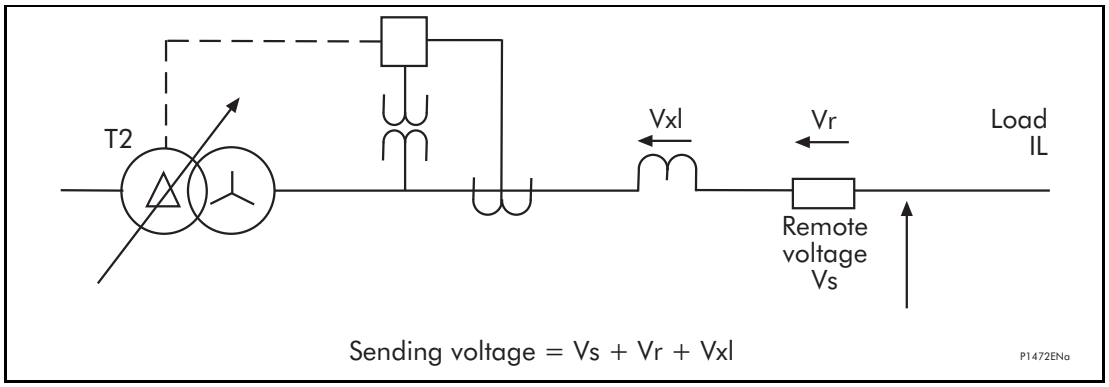


Figure 8: Line drop compensation to regulate system voltage at remote point to tap changer

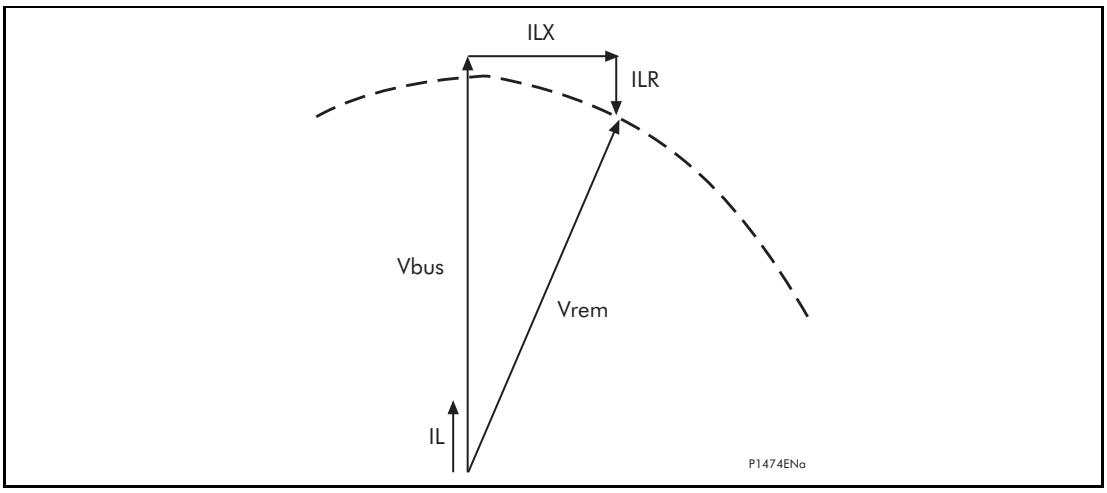


Figure 9: LDC Vector diagram

4.6 Auto, manual and remote operation modes

The relay has the following modes of operation:

AUTO

MANUAL

BLOCK

REMOTE

It may be desirable before carrying out checks during commissioning to prevent tap change initiation by selecting MANUAL operating mode.

The selection of AUTO/MANUAL modes can be made remotely or locally, by a menu setting, a logic input which can be toggled or through the user interfaces. The remote selection of AUTO and MANUAL modes can only be made when link [SD1] is set to '1' or the REMOTE opto-input is energised.

When switched from a locally selected mode to remote, the relay remains in the last locally selected mode until a new mode is selected remotely. The operating modes of AUTO and MANUAL are memorised, so that the relay will revert to the last selected mode following an auxiliary power supply interruption.

Three opto inputs AUTO, MANUAL and REMOTE can be used for local operating mode selection. AUTO and MANUAL select tap change control in service and REMOTE enables remote control of AUTO or MANUAL modes.

In 'MANUAL' mode, the tap change initiating signal is independent of the voltage at the remote end and does not take line drop compensation or circulating current compensation into account. Also, the delay timer is reset instantaneously and runaway protection is disabled as long as MANUAL mode is selected but all other relay functions work as normal. If external switching is used to tap the transformer rather than the relay whilst it is in MANUAL mode then the relay will ignore the start position when it is turned to AUTO mode thus preventing a runaway alarm.

In 'MANUAL' operating mode, three options are available - Block the tap change, Raise voltage or Lower voltage. After each tap change operation has been signaled the selection will automatically return to the idle condition.

Two output relay masks for 'Manual Mode' and 'Auto Mode' are provided to allow an external indication of the operating mode.

4.6.1 Remote change of operating mode

Either link [SD1] must be set to '1' or the REMOTE input mask must be energised before the relay will respond to a remote command to change the operating mode. The 'Mode' command in the STATUS menu is used to remotely or locally select 'Manual' or 'Auto' operating modes. The operating mode is remembered when the relay is powered down and restored on power up. When link SD1=0 the relay will retain its last set operating mode prior to setting SD1=0. When link [SD1] is set to "0" the operating mode cannot be changed via the serial port and the mode command will have no effect on the operating mode in use.

4.6.2 Manual change of operating mode via logic input

The energisation of the opto input allocated with the input mask 'MANUAL' will select the 'Manual' operating mode. In MANUAL mode, energising either 'RAISE' or 'LOWER' input masks will cause the relay to provide an initiating signal to 'Raise' or 'Lower' to the tap changer.

4.7 Paralleled transformers

Primary substation transformers are often operated in parallel in order to improve the security of supply. A common configuration is two transformers positioned adjacently in a substation and feeding a common busbar. Switching is provided to allow the transformers to be separated for maintenance purposes but normally the transformers operate in parallel. Sometimes the two transformers are not alike, sometimes more than two transformers are paralleled and sometimes transformers several miles apart are paralleled.

In practice it is often required to operate two or more tap changing transformers connected in parallel between local busbars.

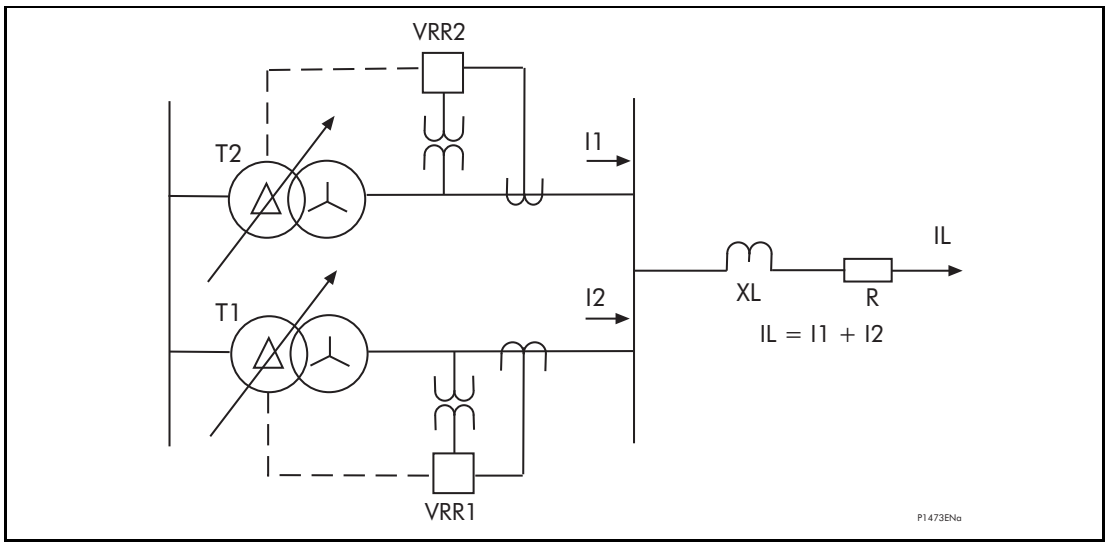


Figure 10: Operation of 2 transformers connected in parallel on local busbars

The total load current is shared between the two transformers as the inverse ratio of impedances and for similar transformers

I1 = I2 and IL = 2 I1 = 2 I2

There are several methods of controlling paralleled transformer groups and these may be classified into two categories.

- those which use a single VRR to operate a group of tap changers
- those which have a VRR in operation for each individual transformer

4.7.1 Master-Follower schemes

Control schemes in category a) above are generally described as master-follower schemes. A transformer whose VRR is operative is designated as a ‘master’ or ‘leader’ and the remaining transformers in the group are designated ‘followers’ or ‘trailers’.

Where the VRR initiates a tap change then the ‘master’ transformer operates and the ‘followers’ are operated to occupy the same service position as the master transformer. For multiple tap change sequences it is necessary to operate a paralleled transformer group step by step i.e. all transformers must occupy the same tap step before the master transformer can perform a second tap change step in a multiple tap step sequence.

There are a number of circuit arrangements for coupling such schemes. One method is to have a potentiometer mechanically coupled to each tap changer so that the position of the moving element corresponds to the selected tap position. The common points of each potentiometer are then interconnected through coupling relays, which operate to correct any tapping disparity with reference to the master transformer. Alternatively, a step by step sequence can be controlled by interconnecting step switches from each tap changer in such a way that the ‘followers’ sequentially come into alignment with the ‘master’ transformer without using coupling relays.

A simple master-follower scheme could be arranged with a KVGC relay on each parallel transformer. The master VRR is set to AUTO mode and the followers set to MANUAL mode. The master relay is set regulate the busbar voltage and operate the local tap changer in the standard way with two of it’s output contacts arranged to give raise and lower commands. The followers are controlled from two more contacts on the master VRR set to give raise and lower commands to the manual raise and lower opto inputs on the follower relays. In this way when the master relay issues a raise or lower command the follower relays will give a raise or lower commands via their manual tap change controls. If the KVGC is configured to use it’s tap position indication then two output contacts can be arranged to indicate even and odd tap positions. These contacts can be wired externally to give an out of step alarm after a time delay if all the transformers are not in step i.e. not all at odd or even tap positions. The circulating current alarm could also be used to indicate an out of step condition for more then one tap position apart if pilot connections are used to extract the circulating current.

Note, the minimum operating voltage of the opto inputs is >35 V and so the maximum limiting series lead resistance for a single opto input is 2000 ohms.

In general master-follower schemes are not suited for parallel control of transformers which have dissimilar tap step increments or number of taps. Such transformer groups require each transformer to be individually controlled within the group, described as category b.

Most master-follower schemes suffer from the disadvantage that following the loss of one transformer on fault, either the voltage control is lost completely (loss of the master) or the LDC setting is increased to twice the required value (loss of the follower). Also, many of the control circuits are complex and rely on satisfactory operation of numerous electrical contacts in step correcting switches, out of step relays etc. and many of the older schemes are unreliable and expensive to maintain.

4.7.2 Instability of individually controlled parallel transformers

Where two or more transformers are operated in parallel by their individual VRR’s then it is inevitable that one transformer may operate earlier than the other transformers in the group. This will result in a disparity of tappings between transformers. The busbar voltage will change only by the percentage change in transformer ratios divided by the number of transformers in parallel. This may be sufficient to correct the voltage and the VRR’s on the other transformers will then reset without operating.

A tapping disparity creates a circulating current, Ic, between the transformers through the busbars. The circulating current is limited by the impedance of the one transformer plus the effective parallel impedance of the remaining transformers in the group. As the transformer impedances are almost entirely reactive, the circulating current will also be reactive. Hence, each transformer in a parallel group sees a nominal load current component Ic which is

leading in one transformer and lagging in the others, relative to the IL component, which is of a predominantly higher power factor.

The effect of the circulating current is to increase the I^2R transformer copper losses and hence the operating temperature of the transformers. For a small tap disparity, one or two taps apart, it can be shown that both these effects are negligible. A large tap disparity can give rise to a circulating current in the transformers which exceeds the full load ratings of the transformers. This effectively sets a limit to the allowable difference between the tap positions of the transformers. There is a temptation to think that tapchangers must always be kept perfectly in step but in practice, this is rarely necessary.

4.7.2.1 Runaway

A situation that must be avoided is where tapchangers run to their opposite limits. For this situation the losses discussed in the previous section would certainly be excessive but, more importantly, voltage control would be completely lost. Unfortunately, the basic VRR with or without LDC will not ensure that parallel transformers are kept in step. In fact if basic VRR's were applied separately to two parallel transformers it would soon lead to runaway and it is important to understand how it would occur.

Even if the systems on each transformer appeared to be identical, component tolerances would cause one VRR to operate before the other. Say, for example that as the load increased and the busbar voltage dropped, VRR2 tapped first to raise the busbar voltage. VRR1 which would have been just about to tap, would see that the voltage was now back within limits and so reset itself without tapping. The tap positions of the two transformers would now differ by one step. The problem is that if the load increased further, the process would be repeated, VRR2 would always be the first to operate. Also, compounding the problem, if the load decreased VRR1 could be the first to tap to lower the busbar voltage. Thus, as the load varied naturally throughout the day, the two transformer tapchangers would diverge and the circulating currents would become excessive. Voltage control would also be lost when the maximum range of the tapchangers was reached. If line drop compensation were in use, the situation would be worse still, in that runaway would occur even without the load changing and therefore even more quickly, see 'Effect of Circulating Current on LDC' below.

Clearly, the VRR's for paralleled transformers must be modified in some way in order to prevent runaway and so to limit circulating currents. Three techniques are widely used:

1. Master-follower
2. Circulating current detection
3. Negative reactance compounding

4.7.2.2 Effect of circulating current on LDC

Consider two similar transformers connected in parallel as shown in Figure 11. The busbar voltage as seen by both VRR's is Vbus. The LDC settings are selected such that

$Vr = IL.R$

$Vxl = IL.X$

Where R is the resistive component of the line and X is the reactive component of the line and IL is at unity power factor.

Figure 12 shows the voltage seen by the relays with transformers T1 and T2 on the same tap position.

If the system now requires a raise voltage tap change and T1 operates before T2, then a circulating current Ic which is almost purely reactive is created as previously described.

Both VRR1 and VRR2 now see the circulating current as an additional load current. In this example transformer T1 is on a higher tap than transformer T2. This will force circulating current to flow from T1 into T2. The current measured by the relay on T1 will therefore be IL + Ic, and the current seen by the relay on T2 will be IL - Ic.

If these currents are applied to relays that are set up for line drop compensation then the circulating current will constitute an error signal.

Figure 13 shows the relay that sees IL - Ic (i.e. T2 which is on too low a tap and would require a raise voltage signal). The circulating current is reactive and is therefore shown leading the load current by 90° (leading because it is negative Ic). This current component will provide resistive and reactive compensation which is likewise leading the Vr and Vxl load current compensation by 90°. The relay is trying to regulate to a remote voltage shown by Vrem. However, the circulating current has caused the relay to be presented with a voltage equal to Vreg. This voltage is much higher than Vrem and if Ic is large enough to take the regulated voltage outside the deadband setting on the relay then the VRR will initiate a lower voltage tap command. This is incorrect as the voltage on this transformer is already too low. Should this occur then the tap disparity is increased and Ic gets larger causing T2 to continue tapping until the lower tap limit is reached and T2 is locked out.

Likewise in Figure 14, transformer T1 sees a current IL + Ic because it is on too high a tap. The net effect of the circulating current in this case is to present a voltage to the relay, Vreg, which is lower than Vrem. If Ic is large enough to take the regulated voltage outside the deadband setting on the relay then the VRR will initiate another raise voltage tap command. This will further increase the tap disparity and hence accelerate the situation until the upper and lower tap limits are reached on both T1 and T2 respectively. For this condition both transformers are locked out and the system voltage can no longer be regulated.

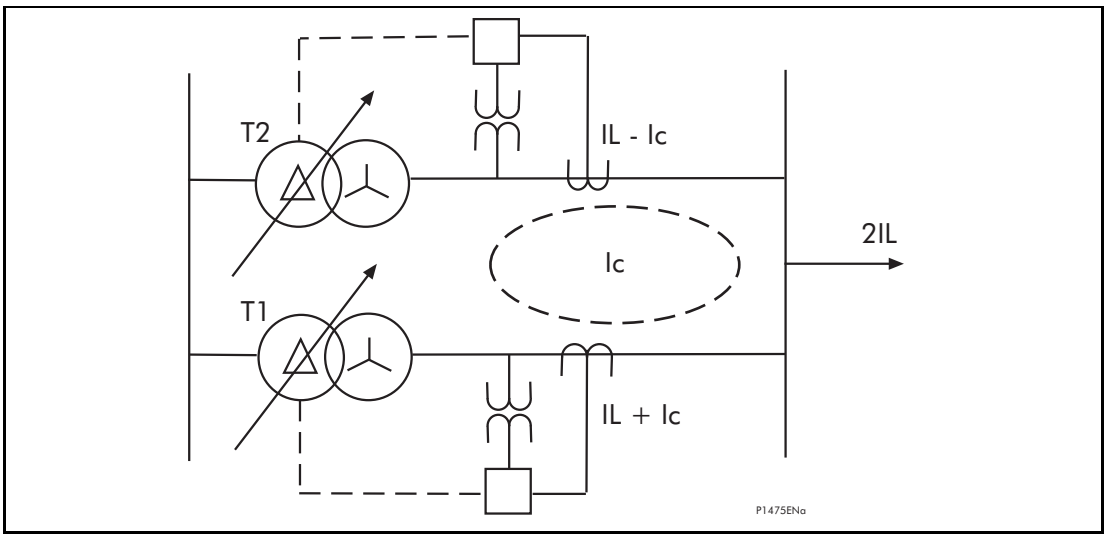


Figure 11: Circulating currents due to tap disparity

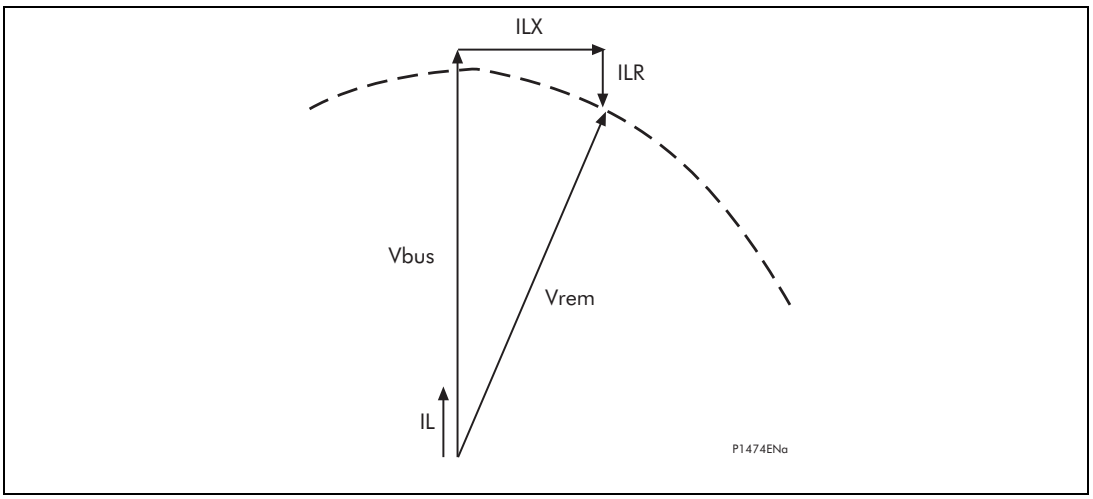


Figure 12: Voltages with transformers T1 and T2 on the same tap position

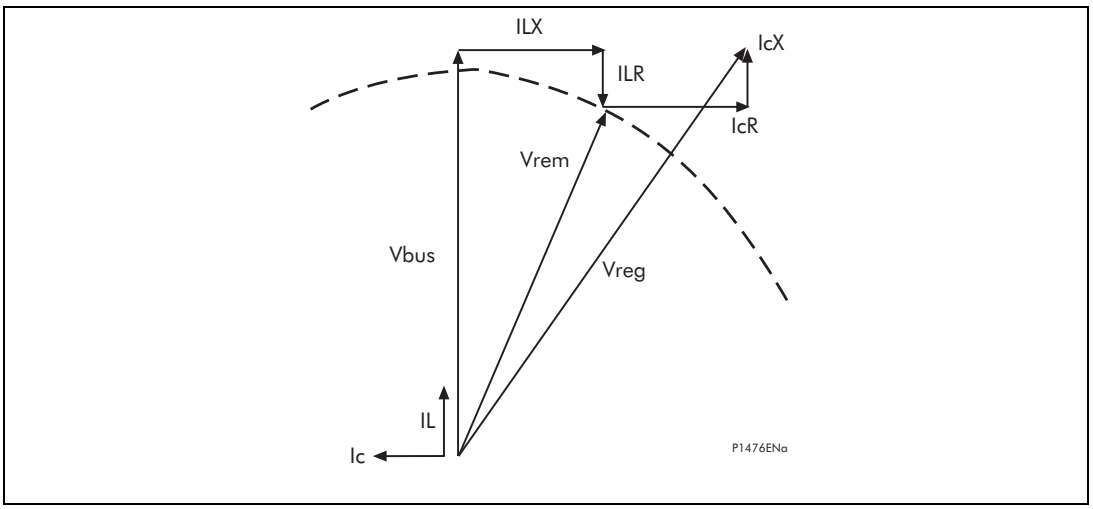


Figure 13: Effects of circulating currents on LDC IL-Ic (Volts Low)

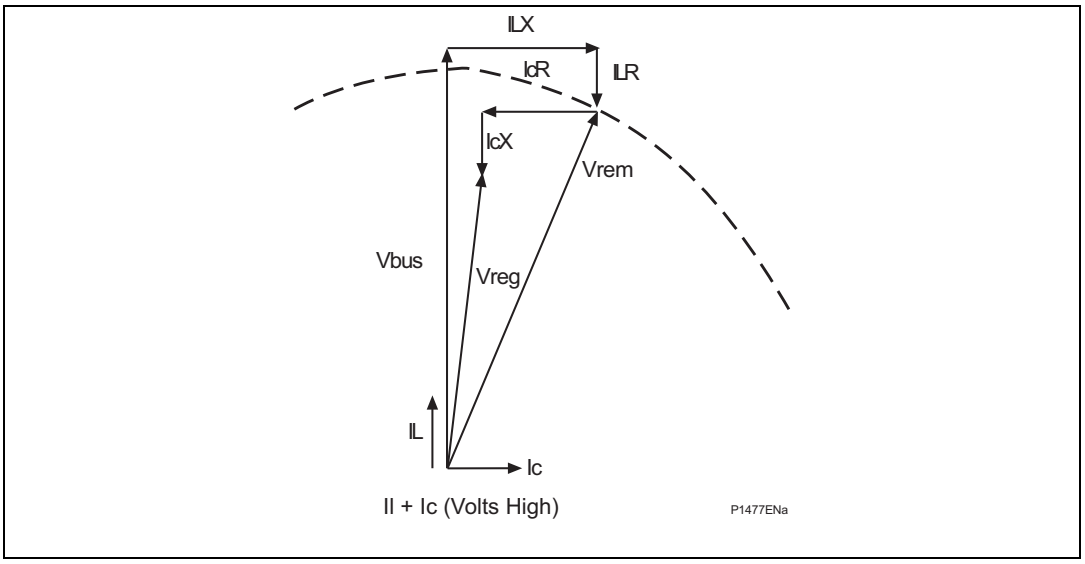


Figure 14: Effects of circulating currents on LDC IL+Ic (Volts High)

4.7.3 Negative reactance compounding

Since the effect of Ic on the Vxl setting is the main contributing factor to stability, a reversal of the Vxl setting would produce components –IL.XL and –Ic.XL. The overall effect is to obtain stable operation as the transformers are being driven towards the same tap position.

Negative reactance control is an alternative form of compensation to pilot wire methods to control circulating current between parallel transformers. It has the advantage over the pilot method of control in that no interconnections are required between individual relays. It is also applicable to parallel transformers of different impedance, tap changers or source buses. Its main disadvantage is that it provides less accurate regulation than the pilot method of control.

For reverse reactance control the V x I setting can be determined from the reactance of the transformer.

$$V \times I \text{ (reverse)} = -\frac{\sqrt{3} \times Ip \times XT}{VT\_ratio}$$

where:

XT = reactance of the transformer

If the reactive compensation used in the above examples were reversed then the result would be as shown by Figures 15 and 16.

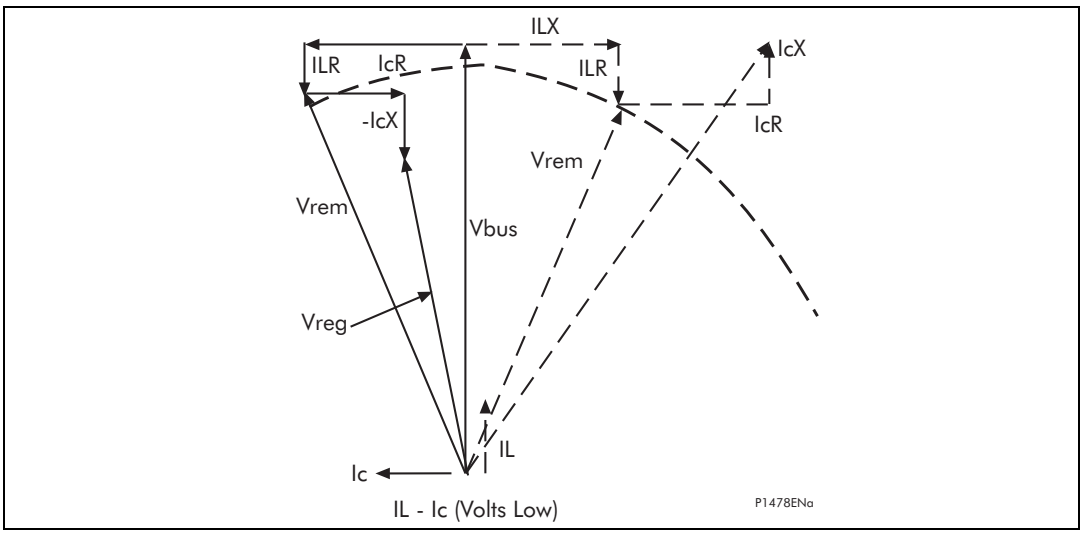


Figure 15: Negative reactance control 1

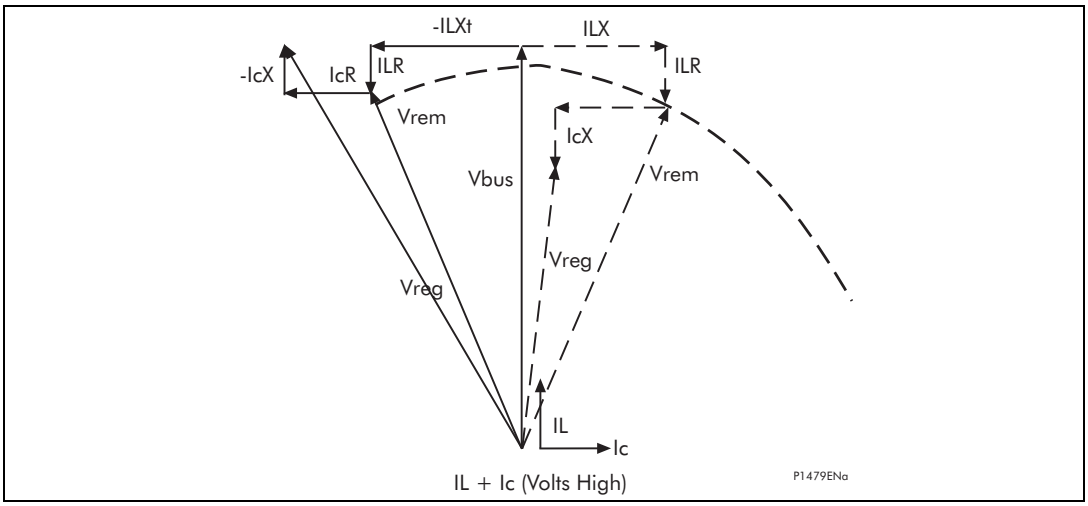


Figure 16: Negative reactance control 2

Figures 15 and 16 mimic Figures 13 and 14 except that in this case all the compensation elements which are reactive have been reversed, the resistive elements being unchanged. It can now be seen that the transformer with a low volts condition is presenting a regulating voltage Vreg which is lower than Vrem (the required voltage) and hence a raise volts command is given. The opposite is true for the transformer that has too high a voltage. The net result is that the transformers are forced together eliminating the circulating current.

Where negative reactance control is used it should be noted that the setting applied to the relay is now based on the transformer reactance and not the line reactance to enable correct compensation. This will introduce an error in regulation which can be seen in both Figures 15 and 16. In both cases when the circulating current is zero the relays will regulate to Vrem. This value of Vrem is different to that from Figures 13 and 14 (also shown as dotted lines on Figures 15 and 16). In practice this error is very small for a unity power factor load current.

The above diagrams demonstrate how reverse reactance control is used to eliminate circulating current. All the above figures also assume that line drop compensation is being used as well. This is not necessarily the case. If LDC is not required then the resistive compensation will not be needed and can be set to zero and only the reactive compensation will be set (in the negative sense). Figure 17 shows this arrangement and assumes that the reverse reactance compounding has eliminated the circulating current. It is noted from the figure that load current will still be passing through the reactive compensation circuit producing a certain amount of compensation (where none should be present). In effect this load current compensation is purely an error signal. Again, in practice this error is small.

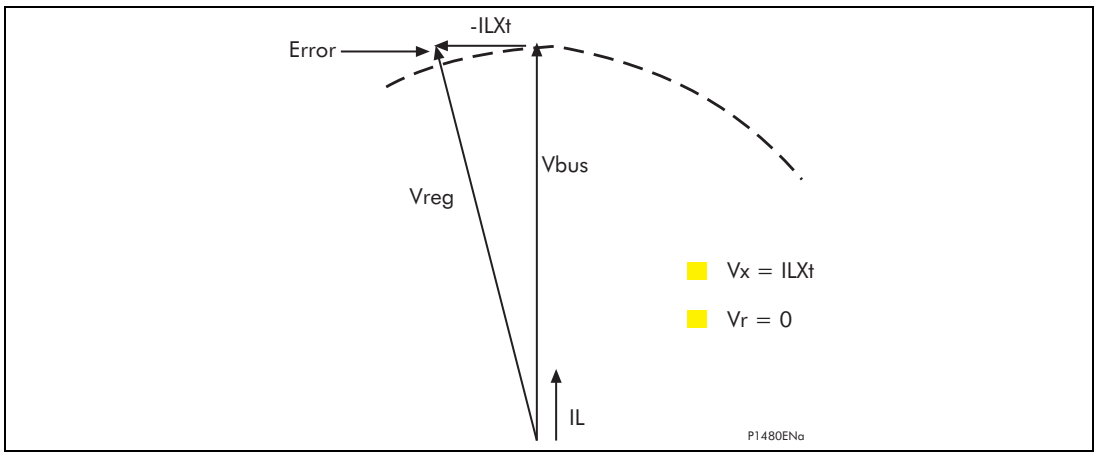


Figure 17: Negative reactance control at unity power factor

Figure 17 shows the effect of load current on negative reactance control with a unity power factor. Where the power factor is not unity then it is possible to use the resistive compensation on the relay to correct for the additional error that would occur because of this. This is shown in Figure 18. In this example Vr is set to:

$$Vr = \frac{\sqrt{3} \times Ip \times XT \tan \phi}{VT\_ratio}$$

where $\cos\varphi$ = power factor of the load

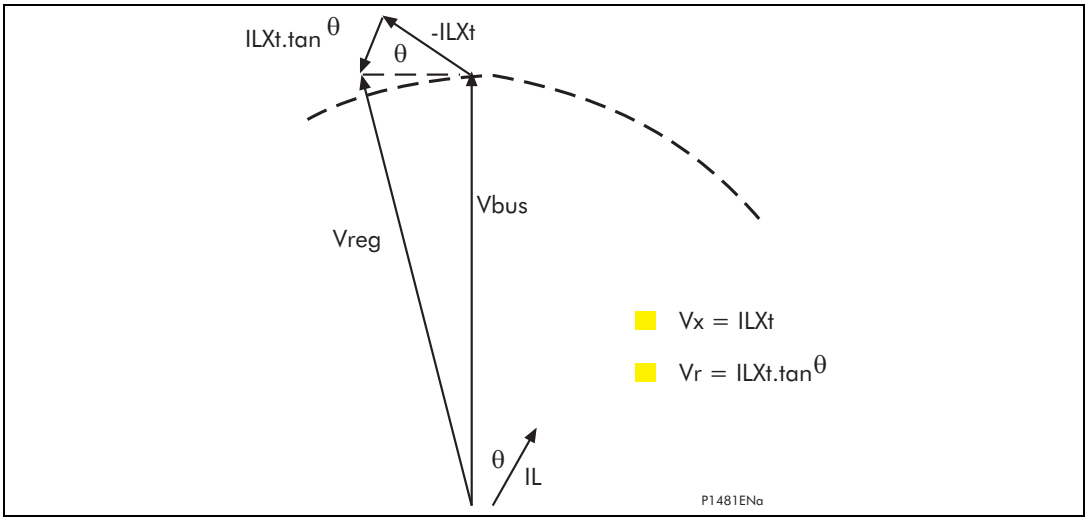


Figure 18: Negative reactance control at non unity power factor

As previously described Figures 15 and 16 show the use of negative reactance control where line drop compensation is also being used. Because the reactive setting, Vxl, is based on the transformer reactance and not the line reactance a small error is introduced at unity power factor currents. If the power factor is decreased this error will increase. It is possible to increase the resistive compensation setting to help decrease this error. However, the resultant error can still be significant at low power factors. Figure 19 demonstrates this. In this example Vr is set to:

$$Vr = \frac{\sqrt{3} \times IP \times (RL + (XL + XT) \tan \phi)}{VT\_ratio}$$

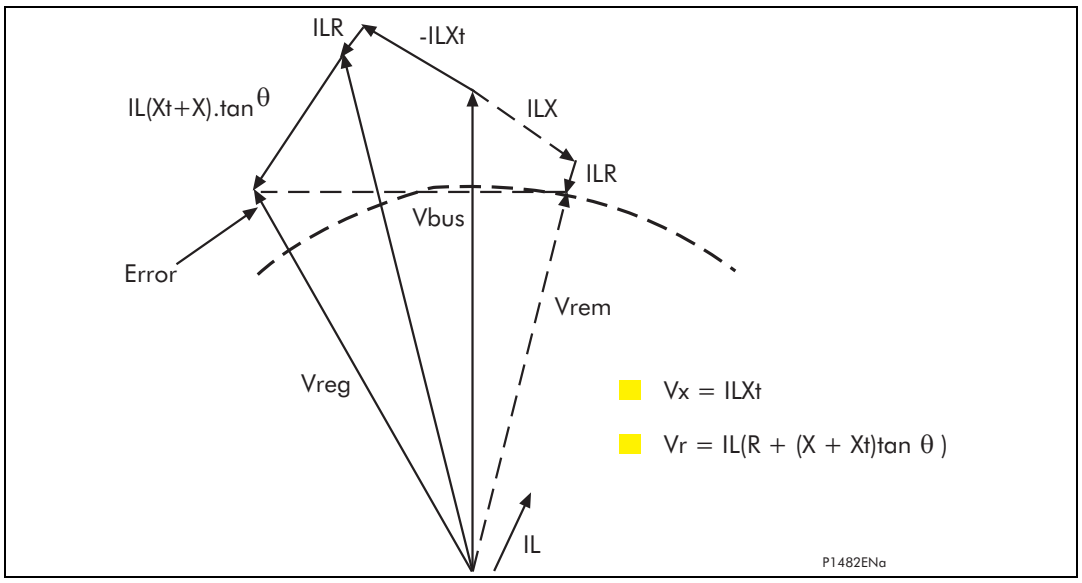


Figure 19: Low power factor with negative reactance control and LDC 1

There is a feature included within the KVGC to overcome the effect of a system with a low power factor. The feature alters the angle between the resistive and reactive compensation. This angle is nominally 90° however by setting it to (90 - θ)° the error can be reduced, see Figure 20. In the KVGC settings the power factor angle θ° is set which alters the angle between the resistive and reactive compensation to (90 - θ)°. Note, the power factor angle setting θ is only visible when Vxl is set negative. In this example Vr is set to:

$$Vr = \frac{\sqrt{3} \times IP \times (RL\cos\phi + XL\sin\phi + XT\sin\phi)}{VT\_ratio}$$

where Cosφ = power factor of the load

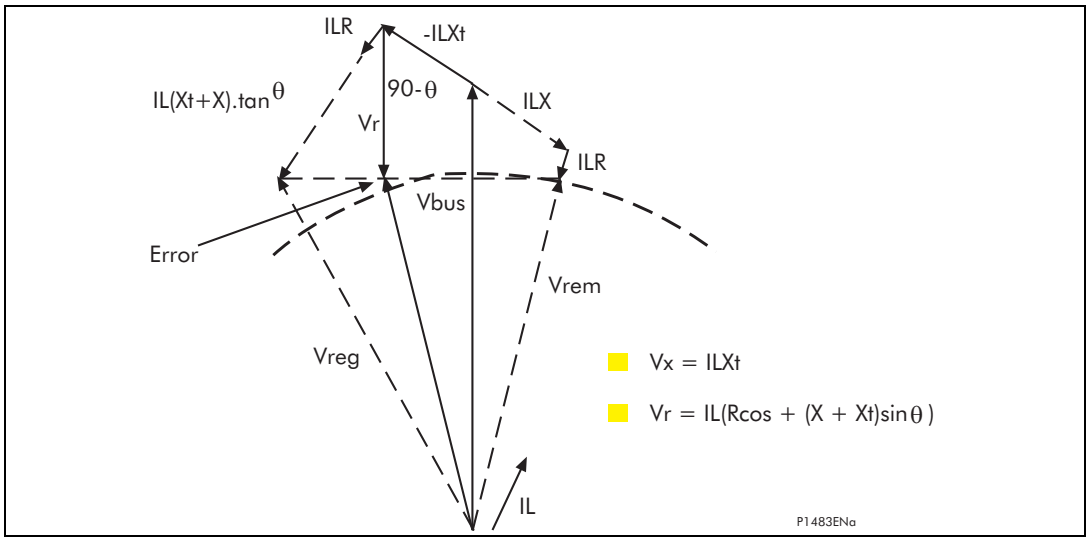


Figure 20: Low Power Factor with Negative Reactance Control and LDC 2

4.7.4 Circulating current control

An alternative method of parallel control of transformers are the circulating current control schemes. These offer the advantage of achieving a fully stable operating scheme whilst retaining both resistive and reactive components of line drop compensation. These schemes are preferred where a large variation in system power factor is envisaged. Where the paralleled transformers are not of similar electrical characteristics then it is necessary to include interposing CTs to provide suitable coupling between transformers.

Circulating current control is obtained by separating the IL and Ic components fed into the LDC circuits. This is obtained by interconnection via pilot wires between the relays in a parallel group. The average of the two currents, IL+Ic and IL-Ic seen by the VRRs, IL, is circulated through the pilot wires. The remaining currents +Ic and –Ic are then circulated through the tertiary windings of the circulating current transformers of the VRRs. These extracted Ic currents are then used to derive a variable compensating voltage Vc which is set to offset the adverse effects of IcXL as previously described.

Precise values of Vc are determined during commissioning procedures to give stable control of two or more transformers in a parallel group. An approximate setting is given by:

$$Vc = \frac{\sqrt{3} \times IP \times XT}{VT\_ratio}$$

where XT = reactance of the transformer.

As can be seen from the above equations the KVGC is set in terms of the volt drop that will occur when rated current is applied to the relay. The relay then applies a level of compensation proportional to the level of circulating current it measures. For example, a setting of Vc = 20 V will produce a compensation voltage equal to 20 *Ic/Irated Volts.

Figure 21 shows two similar parallel transformers where transformer T1 has tapped up before T2. Both VRR1 and VRR2 now see the circulating current as an additional load current. In this example transformer T1 is on a higher tap than transformer T2. This will force circulating current to flow from T1 into T2. The current measured by the relay on T1 will therefore be IL + Ic, and the current seen by the relay on T2 will be IL - Ic. By connecting pilot wires between the relays currents +Ic and -Ic are extracted by the circulating current control circuit which derives a compensation voltage +Vc and –Vc. Figure 22 shows how +Vccvoltage is applied as a compensation voltage to the regulated voltage to increase this voltage so that the VRR will tend to tap down and vice versa for the other VRR. Using this method runaway is avoided even if LDC is not required and the tap changers are forced to be in step with each other if the compensating voltage, Vc, is large enough to take the regulated voltage outside the deadband.

The circulating current inputs from the line CTs for the KVGC202 are terminals 23-24 for 1A rated CTs and 25-26 for 5A rated CTs. The pilot wires are connected between terminals 21-22, see Figure 5 Appendix 3.

The requirement of a pilot wire loop usually limits the use of this scheme to control transformers which are paralleled on a local site. Where this is not the case then reverse reactance schemes must be used.

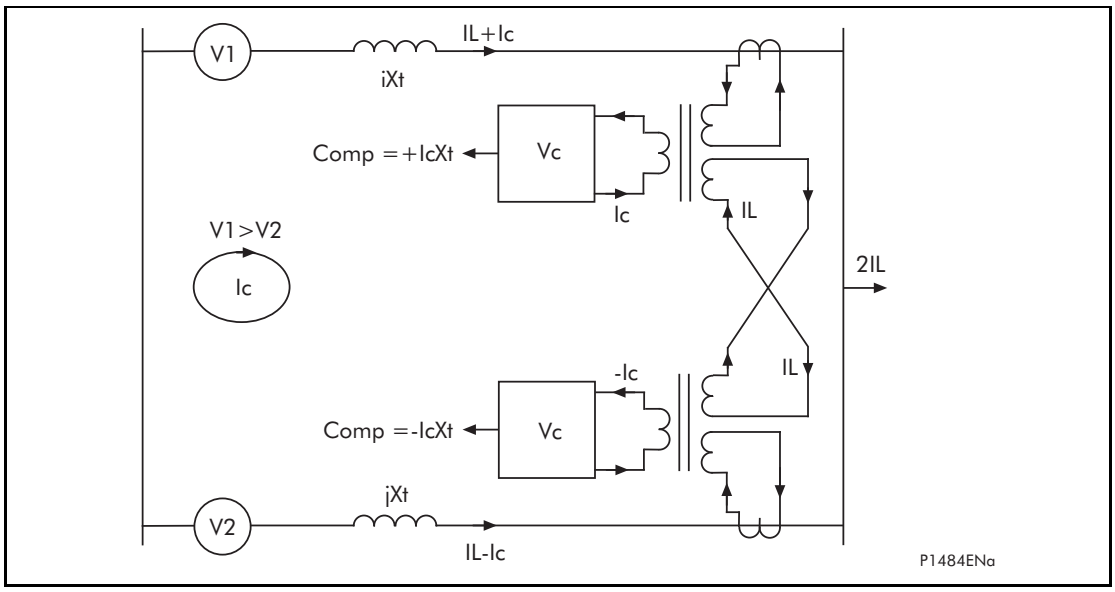


Figure 21: Pilot Method of Circulating Current Control

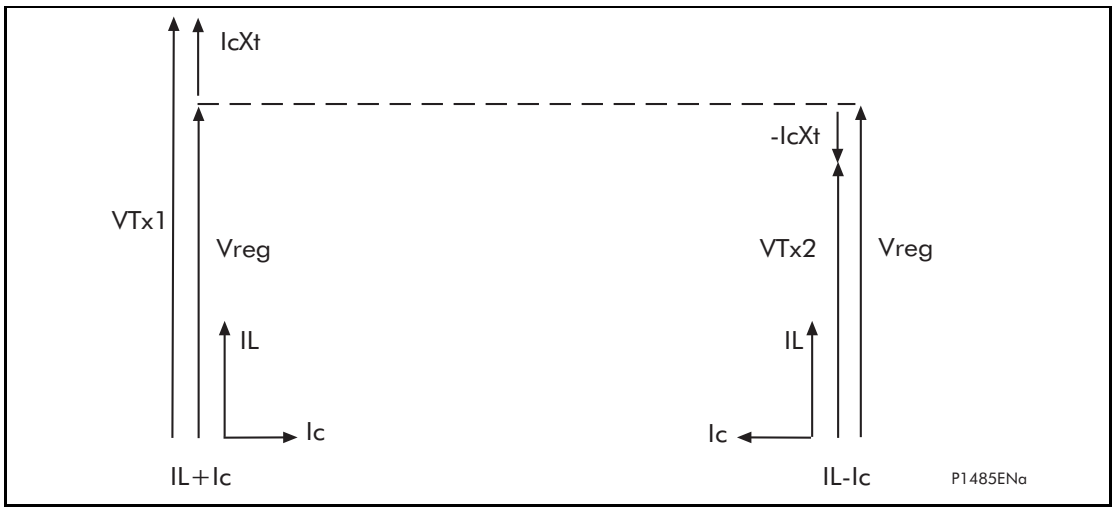


Figure 22: Circulating Current Compensation

4.7.4.1 Independent/parallel control

Where transformers connected in parallel are controlled using the minimum circulating current principle, independent operation is selected by shorting the interconnecting pilot wires as in Figure 23.

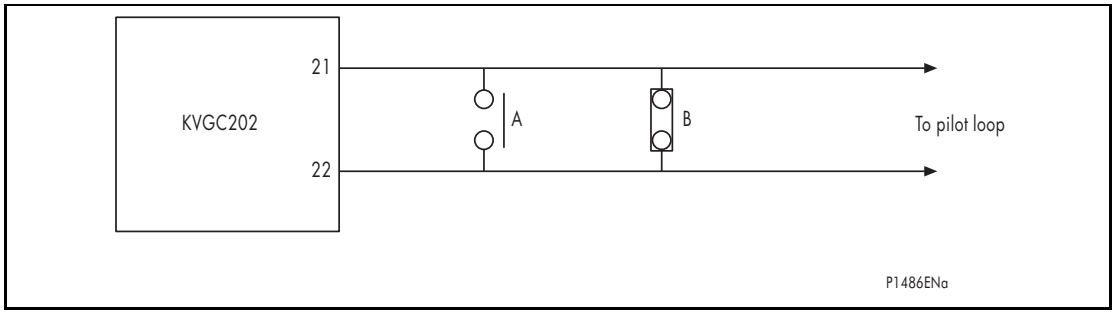


Figure 23: Shorting of Circulating Current Control Pilot Wires

Contact A	–	OPEN	for parallel control
		CLOSED	for independent control
Contact B	–	OPEN	when local LV CB is closed
		CLOSED	when local LV CB is open

4.7.4.2 Circulating current control with LDC

Where parallel transformers feed distribution lines and pilot wires are connected to provide circulating current control a series or a parallel connection of the LDC circuits can be used to provide correct LDC.

4.7.4.2.1 Parallel connection of LDC circuits

Traditionally, the LDC circuits of similar parallel transformers have been connected in parallel. Each relay then measures a current which is proportional to the load current of the power transformer irrespective of the number of parallel transformers in the scheme, see Figure 24. Therefore, when the number of transformers supplying the load changes, the LDC settings on the relay will not need to be adjusted.

Traditionally, when paralleling LDC inputs, it was assumed that the load currents would split equally between paralleled LDC circuits as the LDC impedance of the electromechanical VRR's was large compared to the interconnecting lead resistances.

The KVGC202 has a LDC burden of 0.007 ohms. This is insufficient to ensure that interconnecting lead resistances are negligible. Therefore, when the LDC circuits are paralleled, it is necessary to pad out the burden of the LDC circuits by use of an external swamping resistor.

If both power transformers are the same they will share the total load current, 2 IL. Therefore, with the swamping resistors in the LDC circuit each LDC input to the relay will see the average of the 2 load currents from each transformer, (IL+IL)/2 = IL. If one transformer is out of service then the LDC circuits now sees (2IL +0)/2 = IL. Therefore, when the number of transformers supplying the load changes, the LDC settings on the relay will not need to be adjusted.

However, the voltage drop in the feeders from the busbar is based on the total load current, 2IL, but each LDC circuit only sees half this value, for 2 parallel transformers. Therefore, the LDC resistive and reactive volt drop settings, VR and VXL as calculated earlier for a single transformer must be doubled i.e. based on 2 x rated current. The VR and VXL settings should be adjusted similarly, for 3 or more transformers in parallel, for example the standard settings should be multiplied by 3 for three transformers in parallel.

It should be remembered that when the LDC input CTs are paralleled, the LDC circuits will not see any components of the circulating current between parallel transformers, therefore negative reactance compensation cannot be used to combat circulating current. Only the 'pilot' method of circulating current control or external means of control can be employed.

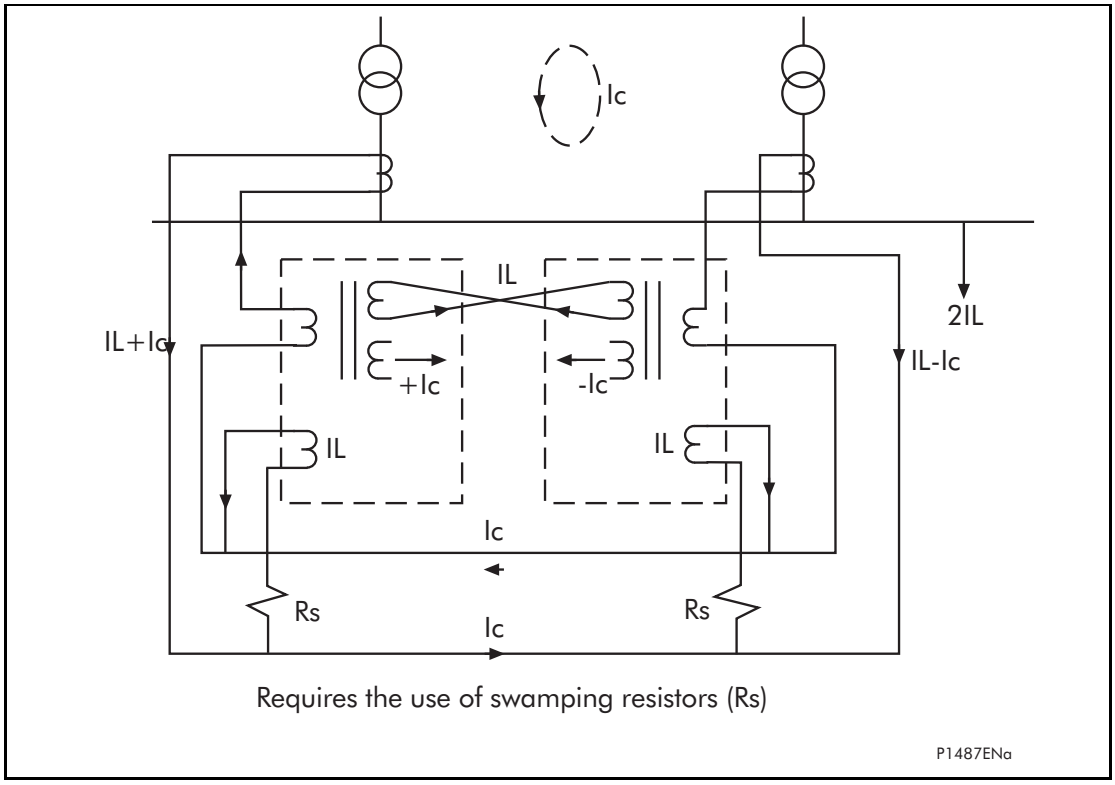


Figure 24: Parallel connection of LDC circuits

The following notes demonstrate how the LDC CTs may be paralleled on a KVGC202 relay.

2RL1 = Lead loop resistance between CT1 and AVR1 plus resistance of AVR circulating current CT input, KVGC202 terminals 23 and 24 for In=1A or terminals 25 and 26 for In=5A.

XM1 = CT1 magnetising impedance which will be ignored due to its high value when CT is unsaturated.

RCT1 = CT1 winding resistance.

RL = Resistance of one lead between AVRs (including any interposing CTs).

CT1 = Driving CT (T1 loaded).

CT2 = Idling CT (T2 loaded).

2IL = Current flowing in line(s) fed by T1/T2 which creates line voltage drop, which is to be compensated for.

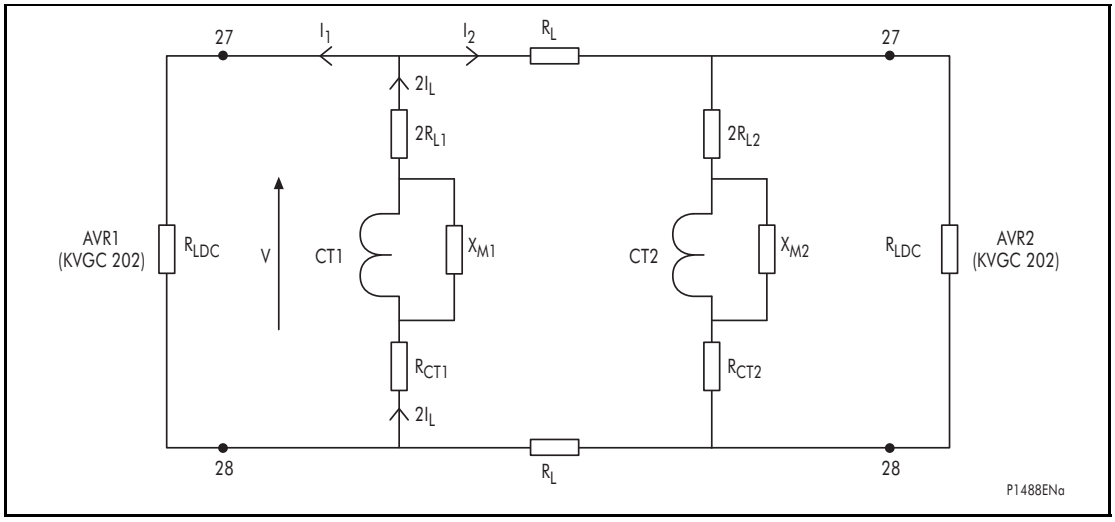


Figure 26: Equivalent circuit diagram for two KVGC202 relays with paralleled LDC inputs

$2I_L = I1 + I2$

$V = I1\ R_{LDC}$

$V = (2I_L - I1)(2R_L + R_{LDC})$

$I1\ RLDC = (2I_L - I1)(2R_L + R_{LDC})$

$$I1 = \frac{2IL\ (2R_L + R_{LDC})}{R_{LDC} + (2R_L + R_{LDC})}$$

Simplifying

$$I1 = \frac{2I_L\left(\frac{2R_L}{R_{LDC}} + 1\right)}{2\left(\frac{R_L}{R_{LDC}} + 1\right)}$$

And

$$I1 = I_L \frac{(2X + 1)}{(X + 1)} \text{ where } X = \frac{R_L}{R_{LDC}}$$

Ideally I1 should equal IL (also I2 = IL), but since RL is not zero, I1 will exceed IL. The required value of X to bring I1 down to 1.05IL will be determined by:

$$1.05I_L = I_L \frac{(2X + 1)}{(X + 1)}$$

$1.05X + 1.05 = 2X + 1$

$0.05 = 0.95X$

$X = 0.0526$

Therefore we require $X < 0.0526$ for $I1 < 1.05IL$

Example 1:

Application of 2 VRRs (1A rated) with direct paralleling

RL = 50m 2.5mm^2 Cu = 0.37Ω

RLDC = 0.007Ω

$X = \frac{R_L}{R_{LDC'}} < 0.0526$ where $R_{LDC'} = R_{LDC} + R_3$

$R_{LDC}' > 19R_L$

$R_{LDC}' > 7.03$

Therefore:

RS > 7.03 – 0.007

> 7.023

Choose a value of Rs = 7Ω.

Required continuous rating = 2In = 2A

Therefore required continuous power rating of RS = 28W.

Allowing a minimum power derating of 50%= 56W, use a resistor rated at 75W.

Therefore use RS = 7 Ω 75W

Note: RS should withstand the maximum main CT secondary rms current for a minimum of three seconds. The maximum output of the main CTs should not exceed three times the steady state current through its connected burden and CT resistance to cause saturation.

Example 2:

Application of two VRRs (5A rated), using 5A: 0.5A interposing transformers to isolate the individual line CTs, to BEBS T2 standard. The British Electricity Board Specification T2 for transformers and reactors uses LDC circuits paralleled through pilots and 5:0.5 A interposing CTs.

Assume:

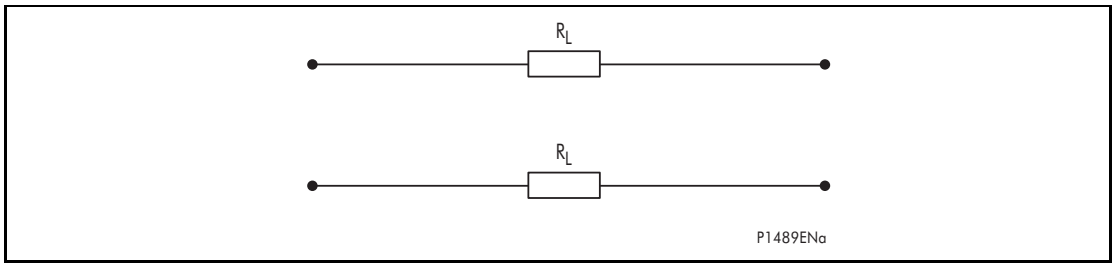


Figure 27:

is equivalent to:

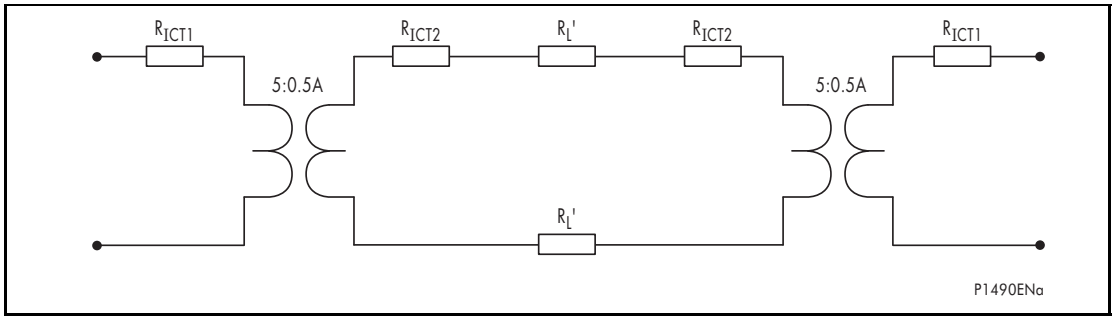


Figure 28:

$$2R_L = 2R_{ICT2} + \frac{2(R_{ICT2} + R_L')}{100}$$

Therefore:

$$R_L = R_{ICT2} + \frac{(R_{ICT2} + R_L')}{100}$$

KVGC202 burden for LDC = 0.007Ω at In

Therefore:

RLDC = 0.007Ω

And

$$X = \frac{R_L}{R_{LDC}} \quad <0.0526$$

Therefore:

$$R_{ICT1} + \frac{(R_{ICT2} + R_L')}{100} \quad <0.0526$$

or RLDC must be increased to RLDC' via a series resistor so that:

$$R_{LDC}' > 19\left(R_{ICT1} + \frac{(R_{ICT2} + R_L')}{100} \right)$$

e.g.

$R_{ICT1} = 0.02$

$R_{ICT2} = 0.3$

$R_L' = 0.2$

This gives:

$$R_{LDC}' > 19\left(0.02 + \frac{(0.03 + 0.2)}{100} \right)$$

> 0.475

$R_{LDC}' = R_{LDC} + R_S$

Therefore:

Rs > 0.475 – 0.007

> 0.468

Choose a value of 0.5Ω.

Required continuous current capability

2In = 10A

Therefore minimum current rating = 50W and, allowing a 50% derating of the component, a 100W resistor is required.

Therefore use RS = 0.5 Ω 100W.

Note: See short time current withstand note given in example 1.

4.7.4.2.2 Series connection of LDC circuits

As an alternative to the parallel connection of LDC circuits, the LDC circuits can be connected in series, see Figure 29. With this series connection the LDC inputs measure the total secondary load current derived from the parallel connection of the line CTs. Therefore, as with the parallel connection when the number of transformers supplying the load changes, the LDC settings on the relay will not need to be adjusted.

With this method of connection the LDC circuits measure the total load current from the two transformers. Therefore, the VR and VXL settings can be based on rated current as for a single transformer shown earlier. If three transformers or more are connected in parallel then care should be taken that the LDC inputs are not thermally over rated.

The current inputs on the KVGC are rated to carry 3.2In continuously. If this is likely to be exceeded then interposing CTs should be used to reduce the current to the LDC inputs and the VR and VX settings should be increased accordingly.

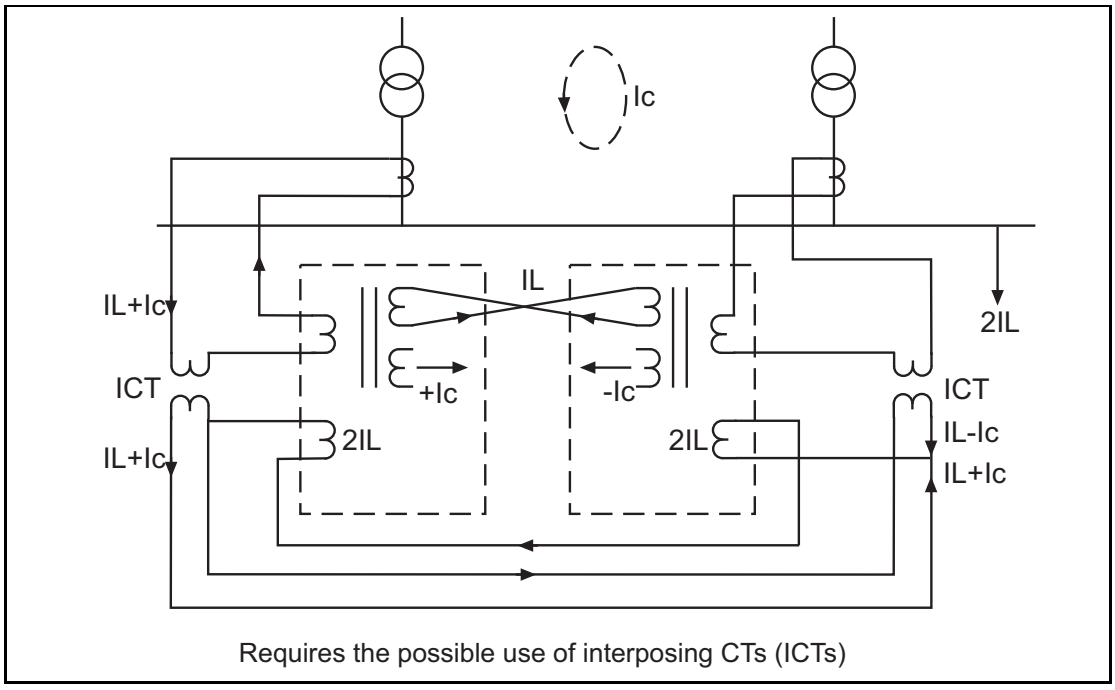


Figure 29: Series Connection of LDC Circuits

4.7.4.2.3 Embedded generation

If embedded generation is installed close to the load centre, then this could cause reduction or possibly reversal of real power flow through upstream transformers. The situation with reactive power is less clear cut, depending on its type and settings, an embedded generator may consume, generate or have zero reactive power. Therefore, overall transformers may experience very significant changes in power factor. This is in contrast to systems without embedded generation where the power factor is usually fairly constant.

Changes in power factor should not cause any degradation of performance in master-follower or circulating current schemes even if embedded generation is installed close to the load centre and causes reversal of real and/or reactive power flow. If embedded generation is installed on a separate line back to the substation then the current feedback used for LDC must be arranged not to include this line.

With negative reactance compounding use of a large negative reactance component will give good performance in terms of keeping tapchangers in step but will increase the susceptibility of the tapchangers to tap erroneously. This is due to increased errors in the regulated voltage caused by changes in the power factor.

Figure 18 shows the errors that can be caused at a non unity power factor. Use of a smaller negative reactance component will slightly increase losses due to circulating currents but will greatly reduce susceptibility to erroneously tapchange due to changes in power factor and will thus allow greater penetration of embedded generation.

To understand the difference in the required magnitude of negative reactance consider the case where the tapchangers are just one step apart. The regulated voltage will be increased in one VRR and decreased in the other by an amount proportional to the negative reactance setting. If this amount exceeds half the deadband, then one or other of the VRRs will immediately call for a tapchange and bring the tapchangers exactly into line. If, on the other hand, the amount is less than half the deadband, it is possible that neither VRR will call for a tapchange. However, as the load varies throughout the day the next tapchange that does occur will bring the tapchangers exactly into line.

Thus to achieve rapid and complete convergence the minimum negative reactance is determined by the size of the deadband, which itself must exceed the step size of the transformer. If, on the other hand the relaxed convergence is accepted the minimum negative reactance is determined by the component tolerances. As explained earlier the tendency for runaway is due to these component tolerances and so to prevent runaway the action of the negative reactance must exceed this tendency.

The KVGC has a reverse current element which can be used to block tap changing or change setting groups where there is reverse power flow caused by embedded generation.

4.8 Supervision functions of a VRR

A range of supervision functions are required to provide a comprehensive voltage regulating control scheme.

The supervision functions are employed to block unwanted tap changes and provide alarms for various system conditions. These include the following:

4.8.1 Runaway protection

Runaway Protection is the feature that detects when a tap change has occurred and checks that it is the result of an authentic tap change signal. An alarm is initiated if:-

- tap position changes in the absence of an initiation signal, or
- tap position changes in a direction which causes the voltage to move further away from the desired voltage Vs.

The run-away protection reads the flags set by the tap change initiation software to determine when a fault condition occurs.

A locking/lockout condition is initiated to inhibit any further tap changes for a runaway alarm if logic link [LOG7] is set to ‘1’.

If auxiliary power to the relay is interrupted then any difference in tap position between power off and power on are counted by the operations counter but will not cause a run-away condition. Any tap position changes occurring during an interruption to the system voltage will be similarly treated.

4.8.2 Undervoltage detection (V<)

The undervoltage detector is set to a threshold V< which defines the minimum working limit of the transformer. If the voltage falls below this limit, any tap change operations that would reduce the voltage further are blocked. An independent time delayed output contact allocated in the Relay Mask ‘V<’ indicates the operation of the element. A common time delay t V< V> is used for the V< undervoltage and V> overvoltage elements.

4.8.3 Undervoltage blocking (V<<)

If the system voltage falls below typically 80% Vs, it is necessary to inhibit the relay ‘Raise V’ and ‘Lower V’ outputs. This is needed to prevent operation for fault conditions on or through the transformer, where the current through the tap changer exceeds the switching capacity of the tap changer mechanism.

If the voltage falls below the V<< threshold the undervoltage detector will operate and instantaneously reset the initial time delay thus inhibiting the relay outputs to ‘Raise V’ or ‘Lower V’ tap change operations. This feature may also be used to determine an operating sequence where a multiple tap change sequence is required to restore nominal reference voltage, see section 4.4.4 ‘Operating Sequences’.

4.8.4 Overvoltage detection (V>)

The overvoltage detector is set to a threshold which defines the maximum voltage on the busbars local to the transformer. If the voltage rises above this limit, any tap change operations that would increase the voltage further are blocked. An independent time delayed output contact allocated in the Relay Mask 'V> indicates the operation of the element. A common time delay t V< V> is used for the V< undervoltage and V> overvoltage elements.

4.8.5 Overcurrent detection (I_L>)

If the total load current (IL) through a transformer exceeds the threshold setting, an alarm is initiated visibly and remotely if the IL> output relay is allocated in relay output mask. If logic Link [LOG3] is set to '1' then an internal relay will operate blocking both 'Raise' and 'Lower' operations thus preventing tap changer operation for fault or overload currents through the transformer. This reinforces the undervoltage blocking previously described.

4.8.6 Undercurrent detection (I_L<)

If the total load current (IL) through a transformer drops below the threshold setting, an alarm is initiated visibly and remotely if the IL< output relay is allocated in relay output mask. If logic Link [LOG8] is set to '1' then an internal software relay will operate blocking both 'Raise' and 'Lower' operations thus preventing tap changer operation.

4.8.7 Circulating current detection (IC>)

The circulating current detector (IC>) limits the tap difference between parallel transformers. The Ic threshold can be set such that it operates when a certain tap disparity level is reached. In the event of excessive circulating current over a certain period (tIC), the Ic detector may be used to internally block the relay for both 'Raise' and 'Lower' operations.

The 'Ic' output relay allocated in the Relay Mask will pick up the excessive circulating current condition to give the alarm indication. If the logic link [LOG2] is set to '1', the alarm condition will also cause blocking of the tap change control operation.

4.8.8 Reverse current detection (I rev)

If the load current (IL) is in reverse direction, the 'Irev' output relay allocated in the Relay Mask will pick up the reverse current condition to give the alarm indication. If the logic link [LOG6] is set to '1', the operation of the tap changer will be blocked for a reverse current. If the logic link [LOG8] is set to '1' then group 2 settings will be selected for a reverse current.

This feature can be used where embedded generation causes reversal of power flow through the transformer, see section 4.7.4.3 for more details.

If embedded generation is installed close to the load centre, then this could cause reduction or possibly reversal of real power flow through upstream transformers.

4.9 Tap position indication

The relay provides an indication of the actual tap position (1 to 40) or (1 to 30) depending on whether the VT voltage or an external ac voltage supply is used for tap position indication (TPI). If the system data link [SD9] is set to '1', the TPI is configured to use the external voltage VT. The advantage of using the external voltage is that the tap position will be indicated even if the transformer is de-energised.

The tap position is determined by applying Vph-ph from a VT or an external voltage to a potential divider and determining the tap position from the output voltage which is fed to the relay on terminals 19-20. The tap position is rounded to the nearest integer. The voltage of each step is given as Vph-ph/Number of resistors in external potential divider or Vexternal/Number of resistors in external potential divider depending on the method of TPI employed. Therefore, the number of taps available TpAvail should be set to the number of resistors in the external potential divider. The external potential divider provided with the relay has 22 resistors for a single unit or 40 resistors with 2 units.

Additional analogue channels are used in the relay to monitor the ac voltage supply for the step voltage calculation. The VT voltage is monitored on terminals 17-18 and the external ac

voltage supply is monitored on terminals 15-16. The relay can indicate tap positions 1 to 40 if the more accurate VT input is used and 1 to 30 if the less accurate external voltage input is used.

As an example of the TPI, if the VT voltage is 100 V and there are 10 taps then a voltage of 10 V would indicate tap position 1 and 20 V tap position 2 etc. Note, if the TPI sees 0 voltage it indicates tap position 1. To make the TPI more stable there is a hysteresis of 65% for the tap change step voltage. So using the above example if the TPI voltage is 30V the tap position will be shown as 3 and the relay will not re-calculate the tap position unless the voltage changes by 65% of the step increment i.e. > 36.5 V or < 23.5 V.

An external potential divider is used to provide a voltage to the KVGC TPI input which is proportional to the tap position. For this purpose a 3EA22A device is available. This unit provides a series chain of 22 x 390 ohm resistors mounted on two PCBs in a 150 mm DIN case.

When used with the KVGC to indicate up to 22 tap positions the regulated voltage is applied across the 22 resistor chain as shown in Figure 30 using the VT voltage. When used with the KVGC to indicate up to 40 tap positions the regulated voltage is applied across a 40 resistor chain in 2 potential divider units as shown in Figure 32 using the VT voltage. Where there are less than 22 taps with one potential divider or 40 taps with two potential dividers on the transformer the higher tap position switches are not connected. The connection of the TPI to the KVGC202 using the VT voltage is shown in Figures 30 and 32. The connection using an external voltage is the same except the external voltage is connected to terminals 15 -16 as well as across the resistor chain, see Figure 31.

When the tap position contacts change over after a tap change command there may be a momentary condition when all the contacts are open which will make the TPI think the tap changer is on the maximum tap position. The KVGC has a time setting tTAPCHANGE, 1 - 3 s (default = 1s), which should be set longer than the maximum time delay between contacts changing position after a tap change command to prevent wrong indication.

Two relay masks are provided in the KVGC202 to indicate ‘Tap Odd’ and ‘Tap Even’ tap positions. For master-follower schemes the taps should be on the same tap shortly after a tap change i.e. all odd or all even tap positions. The Tap Odd and Tap Even output contacts can be used in an external scheme to give an out of step alarm if the VRRs indicate that the tap positions are not all odd or even values.

Two threshold settings Tp> and Tp< are applied to the tap position read. Whenever the value of the tap position read exceeds the set threshold (Tp>) or falls below the threshold (Tp<), the ‘Tap Limit’ output relay allocated in the Relay Mask will pick up to give the alarm indication.

Following cycling of the auxiliary power supply to the relay the last tap position will be retained.

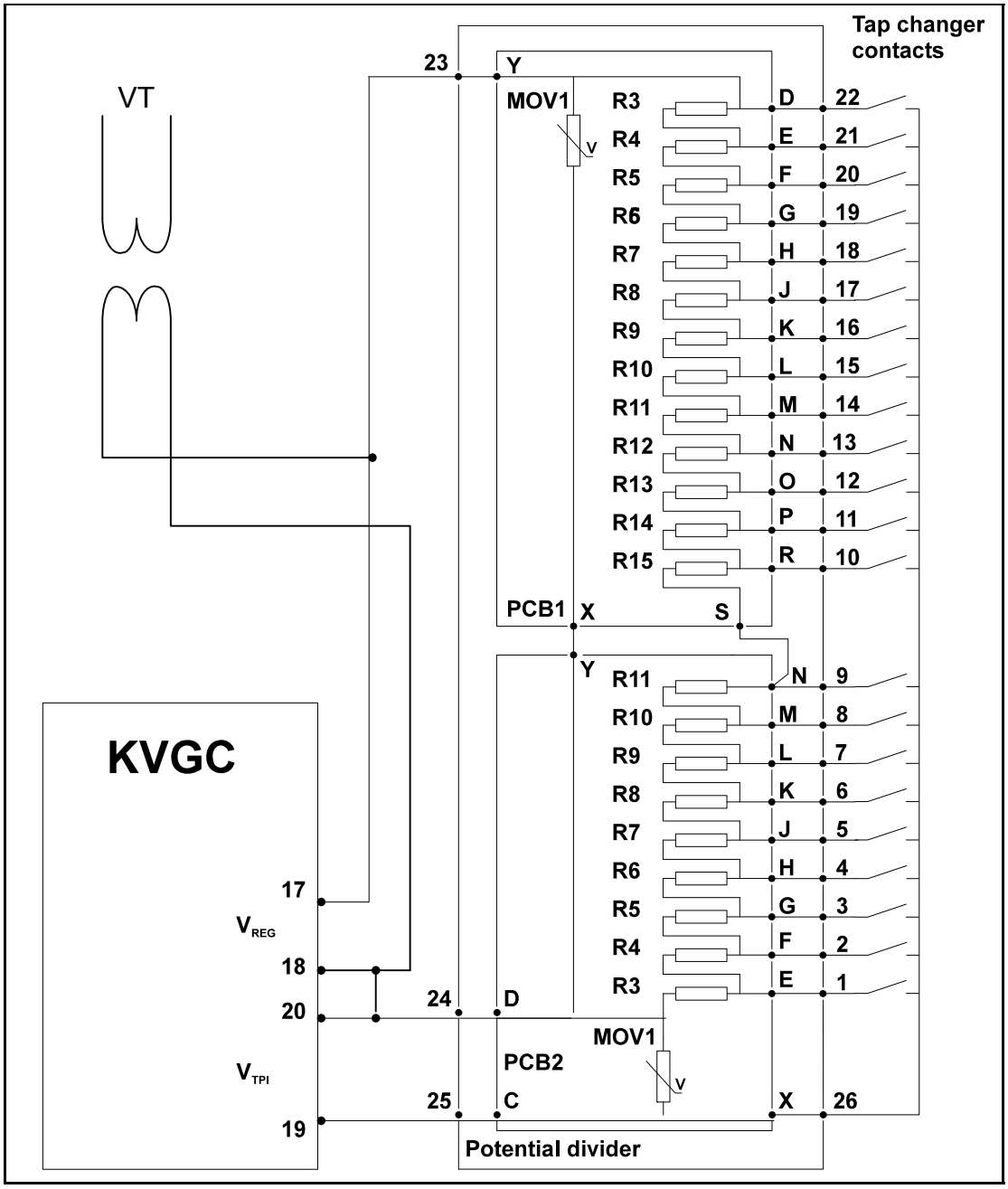


Figure 30: Connection of 22 tap potential divider to KVGC with VT voltage input

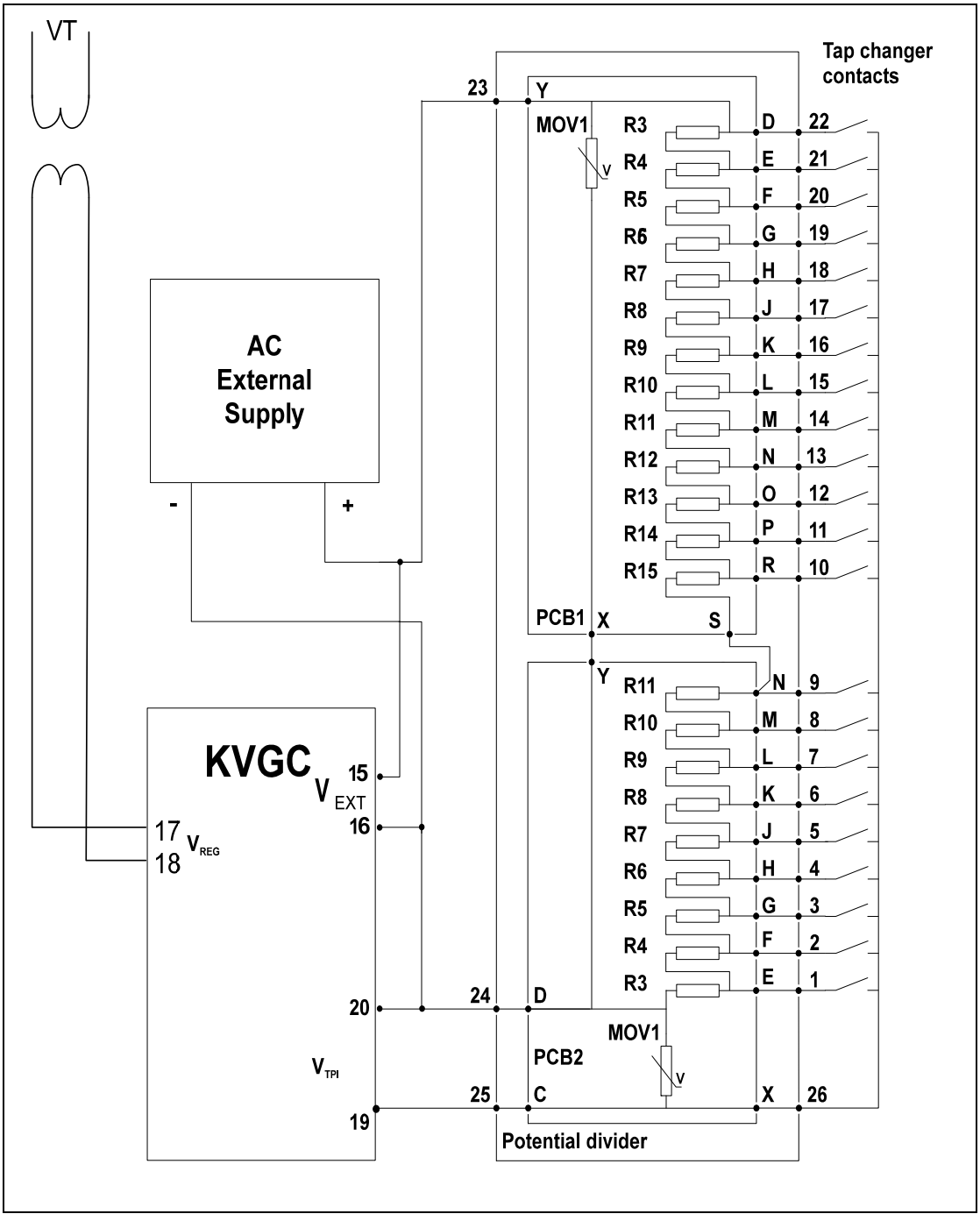


Figure 31: Connection of 22 tap potential divider to KVGC with AC External supply

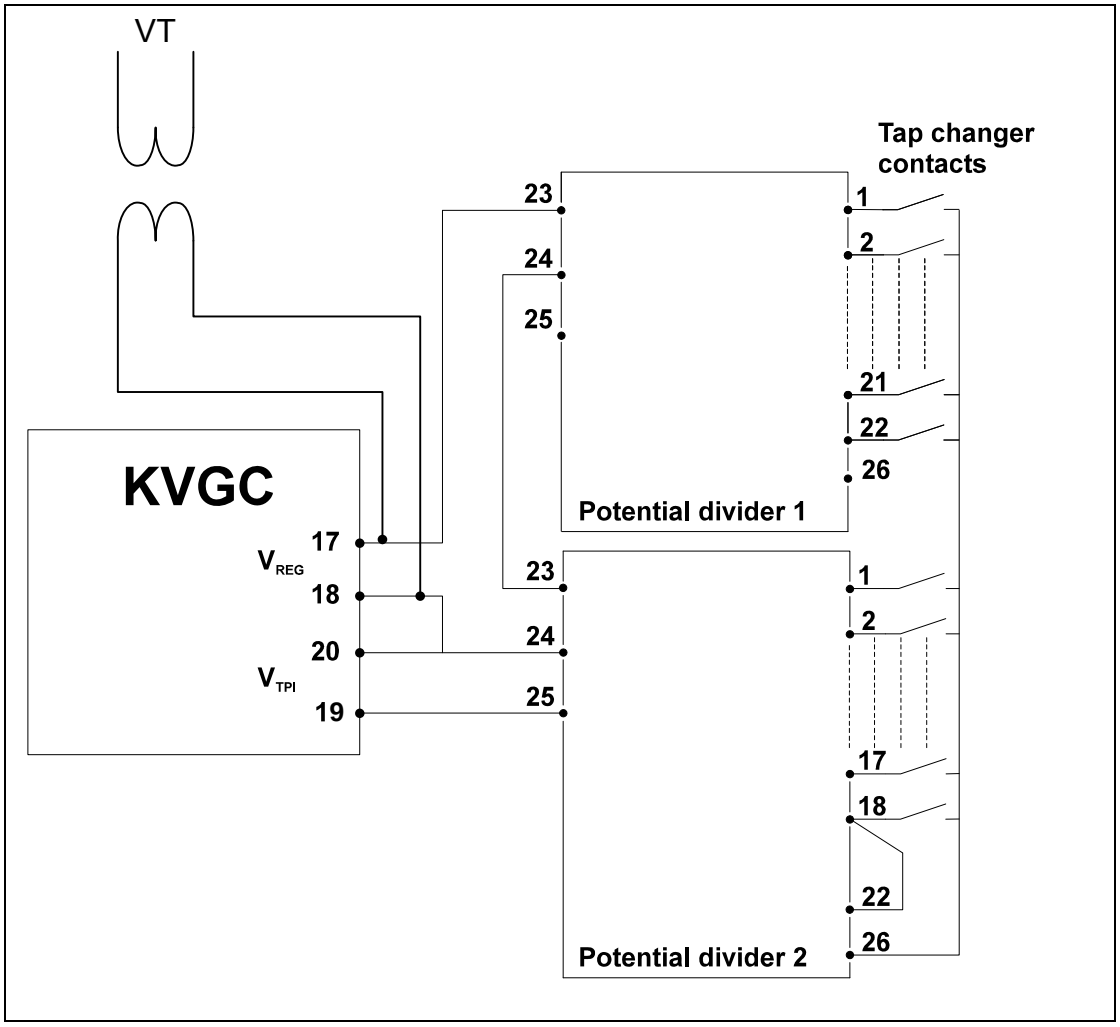


Figure 32: Connection of 40 tap potential divider to KVGC with VT voltage input

4.9.1 Tap changer maintenance

4.9.1.1 Tap change operations counter

The relay provides an indication of the maximum number of tap changer operations. The user may configure the logic to initiate an alarm through the relay masks if the number of tap change operations has exceeded a preset value. If Link [LOG4] is set to '1', the tap change operation will be blocked and hence put the relay out of service when the counter threshold is exceeded.

The "Tap Change Operations Counter" is incremented by 1 each time the tap position is changed. A tap change may be initiated by the internal tap change control functions, manual tap change, local control sequences or remote tap change sequences.

If the auxiliary power is lost the operation counter values and TPI are retained. On power restoration the tap difference between the TPI on power off and power on is incremented to the operations counter.

4.9.1.2 Frequent operations monitor

An alarm is initiated if the number of tap change operations exceeds a certain threshold over a preset time period (tP). The 'FreqOps' output relay allocated in the Relay Mask picks up to give the alarm condition. If Logic Link [LOG5] is set to '1' and the relay is set in 'AUTO' mode, -any further tap change operations are blocked and hence put the relay out of service until the alarm condition is cleared. An event is raised and the number of operations is recorded after every elapsed time period tP. The delay timer and the counter for the tap change operation is reset after the event is logged.

4.9.1.3 Tap changer failure detection

The Tap Changer Failure feature is provided to detect failure of a tap changer to respond to Raise/Lower commands of the relay.

Tap changer failure is detected by checking if the regulated voltage fails to come within the deadband limits within the tFAIL time delay in response to a valid raise/lower command. If a tap change failure is detected the TapFail output relay allocated in the Relay Mask picks up to give an alarm indication and the flags which indicate that a tap change is expected are reset. If the logic link [LOG1] is set to '1' and the relay is in 'Auto' mode, the alarm condition will also cause blocking of the tap change control operation. There is no direct inhibition of the alarm indication except by non selection in the output mask.

The tap fail delay timer is reset instantaneously when the voltage is restored to within the deadband limits.

4.10 Load shedding/boosting

The effective regulated voltage level (Vs) can be lowered or raised by means of the load shedding/boosting option. This allows a system operator to override the VRR automatic regulation to increase or decrease the system voltage supply. Adjusting the system voltage will have a direct effect on the load current, decreasing the voltage will reduce/shed load current and increasing the voltage will increase/boost the load current. Three programmable levels are available settable between 0 to ±10% Vs and can be selected either via K-Bus or by using external contacts to select one of 3 opto inputs assigned to 'Level 1', 'Level 2' and 'Level 3' as required by the user. The stage of the load shedding/boosting can be viewed under the SYSTEM DATA heading of the menu.

When link [SD2] is set to '1', it enables load shedding / boosting in response to commands over the serial port. When [SD2] is set to '0', it prevents load shedding / boosting in response to such commands over the serial port. The opto inputs will override the commands over the serial port.

When the auxiliary supply to the relay is interrupted the states of the load shedding are remembered. This ensures that the level of load shedding is not changed by interruptions of the auxiliary supply.

5. RELAY SETTINGS

5.1 Relay settings

All the settings can be entered into the relay via the front keypad or using a PC with a K-Bus connection. The selection can be made in the menu columns for settings, but password might be required before some settings can be entered. Two setting groups are available to allow the user to set Group 1 to normal operating conditions while Group 2 can be set to cover abnormal operating conditions.

The quantities that require setting are listed below with the adjustment range and step sizes:

Setting	Symbols	KVGC adjustment range	In steps of
Setting voltage	Vs	90 – 139V	0.1V
Dead band	dVs	±0.5% to ±20% of Vs	0.1%
Circulating current	I_C	0.02 – 0.5A (I_n = 1A) 0.1 – 2.5A (I_n = 5A)	0.01A 0.05A
Load current	$I_{L>}$	0.5 – 2A (I_n = 1A) 2.5 – 10A (I_n = 5A)	0.05A
Load current	$I_{L<}$	0 – 1A (I_n = 1A) 0 – 5A (I_n = 5A)	0.10A
Circulating current compensation	Vc	0 – 50V	1.0V
Resistive line drop compensation	Vr	0 – 50V	1.0V
Reactive line drop compensation	Vxl	0 – 50V	1.0V
Reverse reactance control		Internal reversal of V_{XL} vector	
Initial delay (tINIT):	Definite Inverse	0 – 20 secs 20 – 300 secs See Chapter 6.3.3	1 sec 10 secs
Intertap delay	tINTER	0 – 120 secs	0.1 secs
Tap pulse duration	tPULSE	0.5 – 5 secs	0.5 secs
Load (3 Steps) shedding/boosting		0 – ±10% of Vs	1%
Under voltage detection	V<	80 – 130V	1.0V
Over voltage detection	V>	105 – 160V	1.0V
Under voltage blocking	V<<	60 – 130V	1.0V
Total taps available	TapsAvail	1 – 30 Ext volt/1– 40 VT	1
Maximum tap position	TP>	1 – 30 Ext volt/1– 40 VT	1
Minimum tap position	TP<	1 – 30 Ext volt/1– 40 VT	1
Total no. of tap changes	TotalOps>	1 – 10000	1
Tap changer operations	Ops/tP>	1 – 100	1
Time period	tP	1 – 24 hrs	1 hr
Excessive circulating current time delay	t_{IC}	0 – 180 secs	10 secs
Alarm initiation time delay	tFAIL>	0 – 15 mins	30 secs
Power factor angle setting	PF Angle	0 – 90 degrees	1 degree
tV<V>	tV<V>	0 – 300 secs	5 secs

Setting	Symbols	KVGC adjustment range	In steps of
Tap change indication time	t Tap change	1 – 3 secs	0.1 secs

5.1.1 Setting voltage (Vs)

The setting voltage can be selected between 90 and 139V in 0.1 volt steps. The relay compares the system input voltage with this setting voltage and provides raise or lower signals to the tap changer to control the system voltage to be within the set deadband limits.

5.1.2 Deadband (dVs)

The deadband limits are defined as dVs % of Vs setting and are dependent on the tap step increment of the regulating transformer. Typically, dVs % = ±1% for an average tap step increment of 1.4% on the transformer. The deadband can be set between 0.5% to 20% of Vs.

5.1.3 Initial time delay setting (tINIT)

The time delay to initiate a tap change sequence is set by the initial time delay setting between 0 and 300 seconds. A software function link (CTL link 2) determines setting of either definite or an inverse time characteristic.

Selection of a 'definite' initial time delay provides a fixed definite time delay before initiating a tap change and is independent of the voltage deviation. Whereas, selection of an 'inverse' characteristic gives a time delay inversely proportional to the voltage deviation from the setting voltage, Vs.

For inverse characteristic the initial time delay setting defines the operating time delay at the edge of the deadband, N=1. Larger voltage deviations give corresponding faster operating times as shown by the inverse characteristic in Appendix 1. The general expression for inverse time curve:

$$t = k + [(\text{initial time delay setting}) \times (1/N)]$$

where $k = 0.5$ for initial time delay setting -20s

$k = 0$ for initial time delay setting >20s

N indicates % deviation from Vs in multiples of dVs % and is calculated as:

$$N = \left\{ \frac{\left\{ \frac{Vreg - Vs}{Vs} \right\} * 100}{dVs\ \%} \right\}$$

where Vreg = Voltage to be regulated

Vs = Voltage setting

dVs % = Dead band

5.1.4 Inter-tap delay (tINTER)

Where a multiple tap change sequence is required to bring the voltage back to within the deadband limits then the time delay between successive tapping outputs can be set between 0 and 120 seconds. This is normally set to be slightly longer than the operating time of the tap changer mechanism.

The inter-tap delay starts after the first tap pulse has elapsed. When the initial time has elapsed the output continues to give pulsed closure for tap pulse duration at intervals set by the inter-tap delay. Setting the inter-tap delay to 0 seconds results in a continuous output indicated by continuously illuminated 'Control LED'.

5.1.5 Tap pulse duration (tPULSE)

The tap pulse duration can be set between 0.5 to 5 seconds. It is initiated to 'Raise volts' or 'Lower volts' during multiple tap change sequence.

5.1.6 Line drop compensation (Vr and Vxl)

The resistive and reactive controls are set such that the voltage at a point remote to the tap changing transformer can be regulated for varying load conditions.

The resistive line drop compensation can be set between 0 and 50 volts at rated current.

The reactive line drop compensation can be set between -50 to +50 volts at rated current.

$$Vr = \frac{\sqrt{3}.Ip.RL}{VT\ ratio} \qquad Vr = \frac{\sqrt{3}.Ip.XL}{VT\ ratio}$$

Where Ip = primary rated current of line CT

RL = resistive component of line impedance

XL = reactive component of line impedance

VT ratio= ratio of primary to secondary voltages of line VT

Setting the Vxl to –ve value allows selection of reverse reactance for control of circulating current where transformers are connected in parallel. For reverse reactance control the settings are now as below:

$$Vxl\ (reverse) = \frac{\sqrt{3}.Ip.Xt}{VT\ ratio}$$

Where Xt = reactance of transformer

$$Now\ Vr = \frac{\sqrt{3}.Ip}{VT\ ratio}\ (RL\ Cos\ \phi + XL\ Sin\ \phi + Xt\ Sin\ \phi$$

Where Cos ϕ = power factor of load

Note : The setting PF angle setting in the control column should be set to (Cos ϕ) in this case.

The above shows that the effective Vr compensation can vary significantly for varying power factors. Reverse reactance control of parallel transformers is used where transformers are dissimilar or at different locations and the power factor variation is not too great.

5.1.7 Circulating current compensation (Vc)

An alternative method of achieving stable control of parallel transformers is to minimise the reactive circulating current Ic by the introduction of a parallel compensation voltage Vc, which is proportional to Ic. To establish the value of Ic, a pair of pilots must be connected between the KVGC's on the parallel transformers (see Figure 2 in Appendix 3).

The Vc setting can be set between 0 and 50 volts for reactive rated current applied to the circulating current inputs. The Vc setting is determined during commissioning procedures such that optimum stability is obtained for parallel transformers.

An approximate setting is given by:

$$Vc = \frac{\sqrt{3}.Ip.Xt}{VT\ ratio}$$

Circulating current control using Vc setting allows both resistive and reactive components of line drop compensation to be utilised and is independent of power factor variations.

5.1.8 Load shedding/boosting

The effective regulated voltage can be lowered or raised by means of the load shedding/boosting option. Three programmable levels are available which can be selected either remotely via K-Bus or by energising one of the three opto inputs channels. Each level can be set between 0 and ±10% and the selected values can be viewed under the SYSTEM DATA heading of the menu system.

5.1.9 Undervoltage detector (V<)

Independent control is provided to detect undervoltage condition set between 80 and 130 volts. This function may be used to block operations that would lower the voltage further, thus defining the minimum working limit of the transformer and allowing tap changes in such a direction as to restore the regulated voltage. By using the output mask an output contact may be set to operate for an undervoltage condition.

5.1.10 Overvoltage detector (V>)

Independent control is provided to detect overvoltage condition set between 105 and 160 volts. This function may be used to block operations that would raise the voltage further, to prevent excessive voltage on busbars local to the transformers. By using the output mask an output contact may be set to operate for an overvoltage condition.

5.1.11 Under/over voltage detector alarm delay timer (tV<V>)

Alarm initiation time delay can be set between 0 and 300 seconds. An alarm is initiated if either the over or the under voltage detectors have operated.

5.1.12 Undervoltage blocking (V<<)

The undervoltage blocking settings can be set between 60 and 130 volts. Where the system voltage falls below the set value, the undervoltage detector operates and instantaneously resets the initial time delay thus inhibiting the relay outputs to 'Raise' or 'Lower' tap change operations. This feature provides an alternative method to overcome the voltage fluctuations.

5.1.13 Circulating current detector (Ic>)

The excessive circulating current detector settings can be set between 5% and 50% of In. In the event of excessive circulating current over a time period (tIC), set between 0 and 180 seconds, the detector can be used to internally block the relay for both raise and lower operations and set an alarm.

Note: Separate external relay terminals are provided for 1A and 5A inputs.

5.1.14 Overcurrent detector (IL>)

The overcurrent detector setting can be set between 50% and 200% of In. An alarm can be initiated if the load current exceeds this setting.

Note: In for the currents can be set via CONTROL column of the menu system.

5.1.15 Undercurrent detector (IL<)

The undercurrent detector setting can be set between 0% and 100% of In. An alarm can be initiated if the load current drops below this setting.

Note: In for the currents can be set via CONTROL column of the menu system.

5.1.16 Total number of tap change (TotalOps)

The total number of tap operations can be set between 1 and 10000. An alarm is initiated if the number of operations exceeds the set value.

5.1.17 Total taps available (TpAvail)

The total number of taps available can be set between 1 and 40 if the VT is used for tap position indication (TPI) or 1-30 if an external voltage is used. This setting should be set to indicate the number of resistors used in the TPI resistor box. For example if a resistor box with 22 resistors is used "TapsAvail" should be set to 22, regardless of the actual taps available on the transformer.

Two threshold settings TP> (maximum tap position) and TP< (minimum tap position) can also be set between 1 and 40, or 1 and 30 depending on whether the VT or external voltage is used for TPI. An alarm can be initiated if the tap position is outside the set thresholds.

5.1.18 Tap fail time delay (tFAIL)

Alarm initiation time delay can be set between 0 and 15 minutes. An alarm is initiated if the voltage has changed due to tap change operation in response to a valid Raise/Lower command issued by the relay, but is unable to come within the prescribed deadband limits within the period of preset time delay.

5.1.19 Frequent operations (Ops/TP>)(tp)

The number of taps change operations (1-100) in a given time (0-24Hrs) can be set. An alarm is initiated if the number of tap change operations (Ops/TP> exceeds a thresholds over a preset time (tp).

5.1.20 Power factor

The power factor angle can be set between 0 and 90 degrees. This provides compensation for different power factors in the system where negative reactance control is being used.

5.1.21 Tap change indication time (tTap change)

The time interval between tap changes to prevent incorrect TPI can be set to 1-3 secs.

5.2 Setting group selection

The relay has two setting groups, but as supplied only setting group 1 will be visible. To make the second group of settings visible in the menu, set function link SD4 = 1 in the SYSTEM DATA column. The value of the group 2 settings is unimportant when link SD4 = 0, because group 1 settings will be in use by default. The menu cell 000E, in the SYSTEM DATA column, is a read only cell that displays the setting group that is in operation. The logic for the setting group is given in the logic diagram in Appendix 2.

5.2.1 Remote change of setting group

Link [SD3] must be set to “1” before the relay will respond to a remote command to change the selected setting group. Because the command cannot be sustained over the serial link a set/reset register is used to remember the remotely selected setting group. When link SD3 = 1, the set/reset register shall change to 0/1 in response to the respective commands <Set Group 1>/<Set Group 2> via the serial port. When the value of set/reset register is “0” then the group 1 settings shall be in operation and when its value is “1” the group 2 settings will be in operation. The state of this register is stored when the relay is powered down and restored on power up. When link SD3 = 0 the value of the set/reset register will no longer change in response to remote commands and will retain its last set state prior to setting SD3 = 0. When link SD3 = 0 the value of the cell cannot be changed via the serial port and the value of this register will have no effect on the setting group in use.

Note: that if [SD4] = 0 then the group 2 settings will be hidden and group 1 will be active by default.

5.2.2 Manual change of setting group

Link [SD4] must be set to “1” to make the second setting group active. Then manual selection of Setting Group 2 shall be effected by setting link control link CTL2=1 in the CONTROL column of the menu.

5.2.3 Controlled change of setting group

Link SD4 must be set to “1” to make the second setting group active. Now energising a logic input allocated in mask [070A STG GRP2] will select setting group 2. The logic input could be energised via the contacts of one of the output relays so that change of setting group will be in response to some control or supervision functions.

5.3 Initial factory settings

As received the relay will be configured with the settings shown below. The password must first be entered before the configuration settings on the relay can be changed either via keypad or over the serial communications port.

5.3.1 System data settings

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
SYS Password	AAAA															
SYS Function Links	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0
SYS Description	KVGC202 01Fx 1Gx															
SYS Plant Ref.	KVGC202 01Fx 1Gx															
SYS Model No.	KVGC202 01Fx 1Gx															
SYS Frequency	50 Hz															
SYS Relay Address	255															
Alarms	x	x	x	x	x	x	x	x	x	1	0	0	0	0	0	0

5.3.2 Link settings

	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
CTL Links	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOG Links	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0

5.3.3 Initial control settings

Control	Symbol	Factory Settings
CT Ratio		1:1
VT Ratio		1:1
Rated current	I_n	1A
Regulated voltage	Vs	110V
Dead band	dVs	±1%
Circulating current compensation	Vc (volt/I_n)	0
Resistive LDC compensation	Vr (volt/I_n)	0
Reactive LDC compensation (– = reverse)	Vx (volt/I_n)	0
Low power factor LDC compensation	Angle Vr/Vx	0°
Initial definite time delay	tINIT DT	30 seconds
Inter tap delay	tINTER	5 seconds
Tap pulse duration	tPULSE	1 second
LSB Level 1		0
LSB Level 2		0
LSB Level 3		0
Tap change indication time	tTapchange	1 second

5.3.4 Initial logic settings

Logic	Symbol	Factory Settings
Undervoltage total inhibit level (% of Vs)	V<<	80V
Undervoltage blocking limit	V<	100V
Overvoltage blocking limit	V>	120V
Over/under voltage blocking timer	tV<V>	0s
Total time outside dead band to = failure	tFAIL	180s
Excessive circulating current threshold	$I_{c>}$	0.05A (1A)
0.25A (5A)		
Excessive circulating current time delay	tI_C	0s
Line overcurrent threshold	$I_{L>}$	1.2A (1A) 6.0A (5A)
Line under current threshold	$I_{L<}$	0A (1A or 5A)
Total number of taps available	TpAvail	20
Upper tap alarm limit	TP>	16
Lower tap alarm limit	TP<	4
Total number of tap change operations	total ops>	5000
Number of tap changes allowed in time tP	opstP>	40
Time period	tP	24
Relay test hold timer	tTest relay	1s

5.3.5 Preferred use of logic inputs

The following is not mandatory, but it is suggested that it is followed where possible so that different schemes will use the particular logic input for the same, or similar function.

INPUT MASKS	DEFAULT SETTINGS
Remote	00000000
Automatic	00000001
Manual	00000010
Raise V	00000100
Lower V	00001000
Block	00010000
Level 1	00100000
Level 2	01000000
Level 3	10000000
Stg Grp2	00000000

5.3.6 Preferred use of output relays

The following is not mandatory, but it is suggested that it is followed where possible so that different schemes will use a particular output relay for the same or similar function.

RELAY MASKS	DEFAULT SETTINGS
Raise V	00000001
Lower V	00000010
Blocked	00000100
UnBlocked	00001000

RELAY MASKS	DEFAULT SETTINGS
V<<	00010000
V>	0000000
V<	00100000
Tap Fail	01000000
$I_{c>}$	10000000
$I_{L>}$	10000000
Il<	00000000
TotalOps>	00000000
FreqOps	00000000
I_{rev}	00000000
RUN - AWAY	00000000
Tap Limit	00000000
Tap Odd	00000000
Tap Even	00000000
Auto Mode	00000000
Manual Mode	00000000
Select tst rlvs	00000000
Test Relays = [0]	

6. MEASUREMENT, RECORDS AND ALARMS

6.1 Measurement

The measured voltage (Vbc) and phase A current values (IL) and (Ic) are available in real time. The rolling average calculation is used to provide a stable displayed reading of the measured values obtained from the sampled waveforms. It is achieved by averaging the last eight measured or calculated values.

6.1.1 Currents

Current is measured once per power frequency cycle and Fourier is used to extract the fundamental component. Measurements are made for line (IL) and circulating currents (Ic). These values are stored in cell locations 0203 and 0204 respectively.

6.1.2 Voltages

The line voltage (Vbc) is measured directly and stored in menu location 0201. The regulated voltage (Vreg) is calculated by subtracting the line compensation and circulating current compensation voltages from the line voltage (Vbc). This voltage is compared with the reference voltage (Vs) and the deviation in the regulated voltage is adjusted automatically by actuating the tap changer mechanism. The regulated voltage (Vreg) is stored in cell location 0202.

6.1.3 Frequency

The sampling frequency of the A/D converter is synchronised to the power system frequency when there is a signal of sufficient strength to reliably make a frequency measurement. In the absence of a signal to frequency track the sampling frequency defaults to the power frequency setting in menu cell 0009. The measured frequency defaults to the power frequency setting when the current and voltage is zero. The displayed frequency measurement will also be the sampling frequency, but in this case it will read 0 when the frequency tracking stops. The measured frequency is stored in cell location 0206.

6.1.4 Power factor

The real and apparent power is calculated from the measured load current (IL) and line voltage (Vbc) quantities. These are made available in the form of magnitude and phase information or as quadrature fourier vectors (Icos (_vect and Isin (_vect) as illustrated in the diagram below.

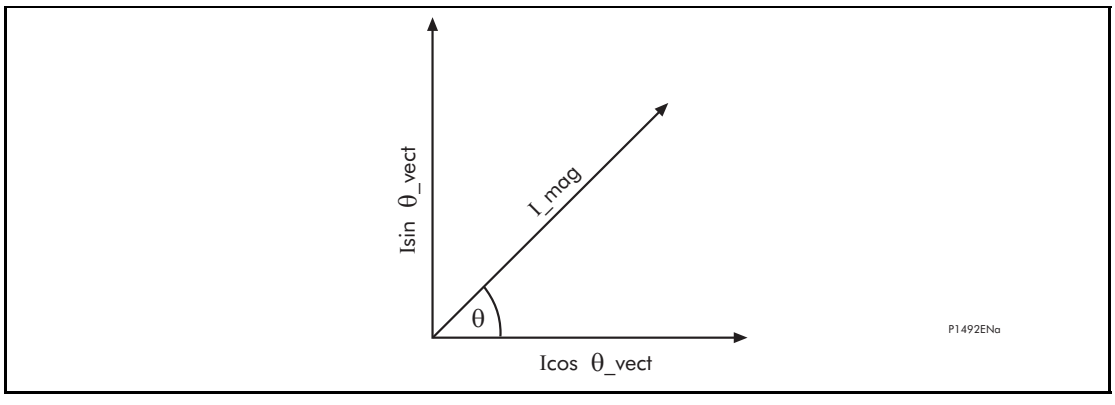


Figure 33:

'Real' power is then calculated from fourier Vbc Icos (vector and the fourier IL Icosϕ. The apparent power is calculated from Vbc and IL magnitudes.

The power factor is calculated by rotating the load current by –90° to make it relative to Vbc. The calculated power pf is converted into a 'numeric quantity (in the form of 'Mantissa, Sign, Exponent, Units') to allow it to be used by the measurement display. The power factor is stored in cell location 0205.

pf = [real power]/[apparent power]

6.1.5 Tap position

The relay provides an indication of the actual tap position (1 to 30). The tap position is determined by applying Vbc to a potential divider and determining the tap position from the output voltage which is measured by the relay. The tap position is rounded to the nearest integer.

The voltage of each step is given by Vbc/Number of taps selected on the relay.

The value of the tap position is stored in cell location 0207.

The highest and lowest tap positions since last reset are also recorded and the values are stored in cell locations 0208 and 0209 respectively. The values can be reset to zero by pressing the [0] key.

6.1.6 Tap changer operations counter

The "Tap Change Operations Counter" is incremented by 1 each time the tap position is changed. The tap change may be initiated by the internal tap change control fuctions, manual tap change, local control sequences or remote tap change sequences. Logic ensures that register is only incremented by 1 in any one tap changing operation. The value of the counter is stored in cell location 020A which can be reset to zero by pressing the [0] key.

6.1.7 Frequent operations monitor

The frequent operations counter is incremented every time a tap change operation is initiated over a preset time (tP), after which an event is raised and the value of the number of operations is recorded. The delay timer and the counter for the tap change operation are reset to zero after the event is logged. The counter can be reset to zero at any time by pressing the [0] key. The value of the counter is stored in cell location 020B.

6.1.8 Time remaining to next tap

The value of location 020C (tREMAIN) is measured and displayed as time remaining to change next tap. When a tap change is initiated (Raise or Lower volts) the value of the initial time delay setting is first stored into this location. When the initial time has elapsed (i.e. decremented to zero) this location is then stored with the value of the inter-tap delay setting. When the inter-tap has elapsed (decremented to zero), a tap change is initiated and the location is re-stored with inter-tap delay value. This process continous until the regulated voltage is within the deadband.

6.2 Event records

Fifty time tagged event records can be stored, after which the oldest record is overwritten. They are stored in non volatile memory and will be lost if the relay is powered down. The event records can only be accessed via the serial communication port and PC software is available to support the automatic extraction and storing of these records.

The following items are recorded with a time tag by the event recorder:

- Changes to settings made locally.
- Alarm status.
- Frequent Operations Monitor.

Events for change in state of an logic input and/or an output relay can be recorded by setting the system data link [SD7]. These two particular forms of events will occur frequently and so by setting [SD7]=0, the recording of these events can be inhibited.

6.2.1 Triggering event records

Event records are triggered automatically in response to the functions listed in Chapter 6.2.

6.2.2 Time tagging of event records

The KVGC202 relay does not have a real time clock. Instead, it has a free-running 32-bit counter that increments every 1 millisecond. When an event occurs, the value of this millisecond counter is recorded (Ta) and stored in the event buffer. When the event is extracted, the present value of the millisecond counter is also sent in the message (Tb). The master station must record the actual time at which it received the event message (Tc). This is equivalent to Tb if we consider the transmission time of the event over the communication network to be negligible. It then calculates how long ago the event occurred by:

How long ago = (Tb – Ta) milliseconds ago

Real time = (time message was received) – (how long ago it occurred)

= (Tc) – (Tb – Ta)

Time tagging is to a resolution of 1 millisecond, the incrementation rate of the counter and remain valid for approximately 49 days. However, the crystal to control the timing has a nominal accuracy of ±50 ppm, is not externally synchronised and has no temperature compensation. It can therefore introduce an error of ±1 second in every 5.5 hours.

The event recording was originally designed for use with automatic extraction programs running on a personal computer (PC) when these timing errors would be insignificant.

6.2.3 Accessing and resetting event records

Event records cannot be viewed on the relay and can only be accessed via the serial communication port of the relay. A PC with suitable software, such as PAS&T, can automatically extract the records, display them on a screen, print them, or store them to either a floppy disc or to the hard disc of the computer.

When a new record is generated the oldest event record is automatically overridden and the event flag set. The PAS&T software responds to this flag and extracts the record. When all records have been read, the event flag resets.

6.2.4 Recorded times

The times recorded for the opto-isolated inputs is the time at which the relay accepted them as valid and responded to their selected control function. This will be 12.5 ±2.5ms at 50 Hz (10.4 ±2.1ms at 60 Hz) after the opto-input was energised. The time recorded for the output relays is the time at which the coil of the relay was energised and the contacts will close approximately 5ms later. Otherwise, the time tags are generally to a resolution of 1ms for events and to a resolution of 1μs for the samples values.

6.3 Alarm records

6.3.1 Watchdog

The watchdog relay will pick-up when the relay is operational to indicate a healthy state, with its “make” contact closed. When an alarm condition is detected that requires some action to be taken, the watchdog relay will reset and its “break” contact will close to give an alarm.

The green LED will usually follow the operation of the watchdog. It will be lit when the relay is powered-up, operational and no abnormal conditions have been detected for healthy conditions.

The watchdog can be tested by setting alarm flag 6 to “1” in menu cell 0022 in the SYSTEM DATA column of the menu.

6.3.2 Alarm indication

The alarm LED will flash when the password has been entered. It will be lit and remain steady when an internal fault has been detected by its self test routine. The alarm flags can then be accessed to determine the fault, provided the relay is still able to perform this function. See chapter 3, Chapters 3.3.5 and 3.6 for more information on alarm the flags.

6.3.3 Blocked indication

When the tap change operation is blocked (RaiseV and LowerV), it is indicated by a CONTROL LED and a relay output contact (BLOCKED) allocated in the relay mask. The tap change operation can be blocked for any of the following conditions:

- Tap change failure [Tfail)
- Number of tap change operations [TotalOps]
- Frequent tap change operations [FreqOps]
- Run Away protection [RunAway]
- Block logic input mask (0706) is manually initiated

The CONTROL LED will be flashing for any of the above conditions except for manual blocking, for which it will illuminate continually. It is also lit permanently during tapping if the inter tap delay time is set to zero for continuous tap change operation.

6.4 Functional alarms

A relay output should be allocated in the relay mask to give an alarm condition for any of the functions described in this Chapter. The relay masks can be found in chapter 3, Chapter 3.3.12. of this service manual. The logic diagram showing the logic for each of the functions can be found in Appendix 2.

6.4.1 Raise/lower volts indication

Relay outputs can be allocated in the relay masks to give an indication for raise and lower volts tap change.

6.4.2 Blocked indication

Relay output can be allocated in the relay masks to give an indication for the blocked condition.

6.4.3 Undervoltage blocking (V<<)

If the system voltage falls below the undervoltage blocking setting value, the undervoltage detector will operate and instantaneously reset the initial time delay thus inhibiting the relay outputs to ‘Raise’ or ‘Lower’ tap change operations.

V<< output relay allocated in the relay mask will pick up the undervoltage blocking condition to give the alarm indication.

The pick-up/drop-off ratios on the undervoltage blocking detection is +5% of the threshold setting.

6.4.4 Undervoltage detection (V<)

The undervoltage detector block operations that would lower the voltage further thus defining the minimum working limit of the transformer and allowing tap changes in such a direction as to restore the regulated voltage.

V< output relay allocated in the relay mask will pick up the undervoltage detection condition to give the alarm indication.

The pick-up/drop-off differentials on the undervoltage detectors is +1% of the threshold setting.

6.4.5 Overvoltage detection (V>)

The overvoltage detector will block operations that raise the voltage, to prevent excessive voltage on busbars local to the transformer.

V> output relay allocated in the relay mask will pick up the overvoltage detection condition to give the alarm indication.

The pick-up/drop-off differentials on the overvoltage detector will be –1% of the threshold setting.

6.4.6 Circulating current detection (Ic>)

The circulating detector (IC>) limits the tap differences between parallel transformers. In the event of excessive circulating current over a certain period (tIC), the Ic detector will be used to internally block the relay for both 'Raise' and 'Lower' operations.

Ic> output relay allocated in the relay mask will pick up the excessive circulating current condition to give the alarm indication. If the logic link [LOG2] is set to '1', the alarm condition will also cause the blocking of the tap change control operation.

The pick-up/drop-off differentials on the excessive circulating current is –5% of the threshold setting.

6.4.7 Overcurrent detection (IL>)

If the load current (IL) through a transformer exceeds the threshold setting, IL> output relay allocated in the relay mask will pick up the excessive load current condition to give the alarm indication. If the logic link [LOG3] is set to '1', the operation of tap changer will be inhibited for fault or overload current through the transformer.

The pick-up/drop-off differentials on the overcurrent detector is –5% of the threshold setting.

6.4.8 Undercurrent detection (IL<)

If the load current (IL) through a transformer drops below the threshold setting, IL< output relay allocated in the relay mask will pick up the insufficient load current condition to give the alarm indication. If the logic link [LOG8] is set to'1', the operation of tap changer will be inhibited. The pick-up/drop-off differentials on the undercurrent detector is +5% of the threshold setting.

6.4.9 Reverse current blocking (Irev)

If the load current IL) is in reverse direction, Irev output relay allocated in the relay mask will pick up the reverse current condition to give the alarm indication. If the logic link [LOG6] is set to '1', the operation of tap changer will be inhibited and the delay timer will be reset instantaneously.

If the system link (SD6) is set to '1' then the relay will use group 2 settings.

6.4.10 Run-Away

Run-Away is the feature that monitors the tap position and checks that an authentic tap change signal has been initiated. An alarm is initiated if:

- tap changer operates in the absence of an initiation signal or
- tap changer operates in a direction which causes the voltage to move further away from the desired voltage Vs.

Blocking condition is initiated to inhibit any further tap changes if logic link [LOG7] is set to '1'.

6.4.11 Tap position indication

The relay provides an indication of the actual tap position. If the tap position read exceeds the minimum (Tp<) and maximum (Tp>) thresholds, an output relay (TapLimit) allocated in the relay mask operates to give an alarm indication.

6.4.12 Tap change operations counter

The relay provides an indication of the maximum number of counts of the tap changer operations (TotalOps). A relay totalises the number of tap change operations every time the relay initiates a tap change signal to the tap changer (RaiseV or LowerV) due to voltage deviation.

When the number of tap change operations exceeds a preset value, TotalOps output relay allocated in the relay mask will initiate an alarm condition. If link [LOG4] is set to '1', the tap change operation is blocked and hence putting the relay out of service.

6.4.13 Frequent operations monitor

The relay also provides the tap changer maintenance mechanism to monitor the frequent operations (FreqOps) of the tap changer operations. A counter is incremented as soon as the change in tap position is detected and the maintenance timer is incremented by the time elapsed since last function call in 10ms periods.

When the number of tap change operations exceed a certain threshold over a preset time period, FreqOps output relay allocated in the relay mask will initiate an alarm condition. If logic link [LOG5] is set to '1' and the relay is set in 'Auto' mode, any further tap change operations is blocked and hence putting the relay out of service until the alarm condition is cleared by pressing the [0] key.

The values of the timer and counter can be reset to zero when any of the following has occurred:

Tap change is blocked

After the events have been recorded after every elapse of time period

The maintenance timer has exceeded the preset time period

Alternatively, a reset cell command can be sent via the serial communication port. These cells are password protected and cannot be reset if the password has not been entered.

6.4.14 Tap changer failure mechanism

The Tap Changer Failure feature is provided to detect failure of a tap changer to respond to Raise/Lower commands of the relay.

Tap changer failure is detected by checking if the regulated voltage fails to come within the deadband limits within the tFAIL time delay in response to a valid raise/lower command. If a tap change failure is detected the TapFail output relay allocated in the Relay Mask picks up to give an alarm indication, tap changing is blocked and the flags which indicate that a tap change is expected are reset. If Logic Link [LOG1] is set to '1' and the relay is set in 'AUTO' mode, any further tap change operations are blocked and hence put the relay out of service until the alarm condition is cleared. There is no direct inhibition of the alarm indication except by non selection in the output mask. If [LOG1] is set to '0' the alarm and block will be reset when the voltage is restored to within the deadband limits.

The tap fail delay timer is reset instantaneously when the voltage is restored to within the deadband limits.

7. CONTROL FUNCTIONS AND SERIAL COMMUNICATIONS

7.1 Courier language protocol

Serial communications are supported over K-Bus, a multi-drop network that readily interfaces to IEC 60870-5 FT1.2 Standards. The language and protocol used for communication is Courier. It has been especially developed to enable generic master station programs to access many different types of relay without the continual need to modify the master station program for each relay type. The relays form a distributed data base and the Master Station polls the slave relays for any information required.

This includes:

- Measured values
- Menu text
- Settings and setting limits
- Event records
- Plant status

Software is available to support both on-line and off-line setting changes to be made and the automatic extraction and storage of event records as described in Chapter 6.3.

Courier is designed to operate using a polled system, which prevents a slave device from communicating directly to a master control unit when it needs to inform it that something has happened; it must wait until the master control unit requests the information. A feature of Courier is that each piece of information is packeted by preceding it with a 'data type and length' code. By knowing the format of the data the receiving device can interpret it.

The Courier Communication Manual describes various aspects of this language and other communication information necessary to interface these devices to other equipment. It gives details on the hardware and software interfaces as well as guidelines on how additional devices should implement the Courier language so as to be consistent with all other devices.

7.2 K-Bus

K-Bus a communication system developed to connect remote slave devices to a central master control unit, thus allowing remote control and monitoring functions to be performed using an appropriate communication language. It is not designed to allow direct communication between slave devices, but merely between a master control unit and several slave devices. The main features of K-Bus are: cost effectiveness, high security, ease of installation and ease of use.

The KVGC202 voltage regulating relay has a serial communication port configured to K-Bus Standards. K-Bus is a communication interface and protocol designed to meet the requirements of communication with protective relays and transducers within the power system substation environment. It has the same reliability as the protective relays themselves and does not result in their performance being degraded in any way. Error checking and noise rejection have been of major importance in its design.

7.2.1 K-Bus transmission layer

The communication port is based on RS485 voltage transmission and reception levels with galvanic isolation provided by a transformer. A polled protocol is used and no relay unit is allowed to transmit unless it receives a valid message, without any detected error and addressed to it. Transmission is synchronous over a pair of screened wires and the data is FM0 coded with the clock signal to remove any dc component so that the signal will pass through transformers.

With the exception of the Master Units, each node in the network is passive and any failed unit on the system will not interfere with communication to the other units. The frame format is HDLC and the data rate is 64kbits/s.

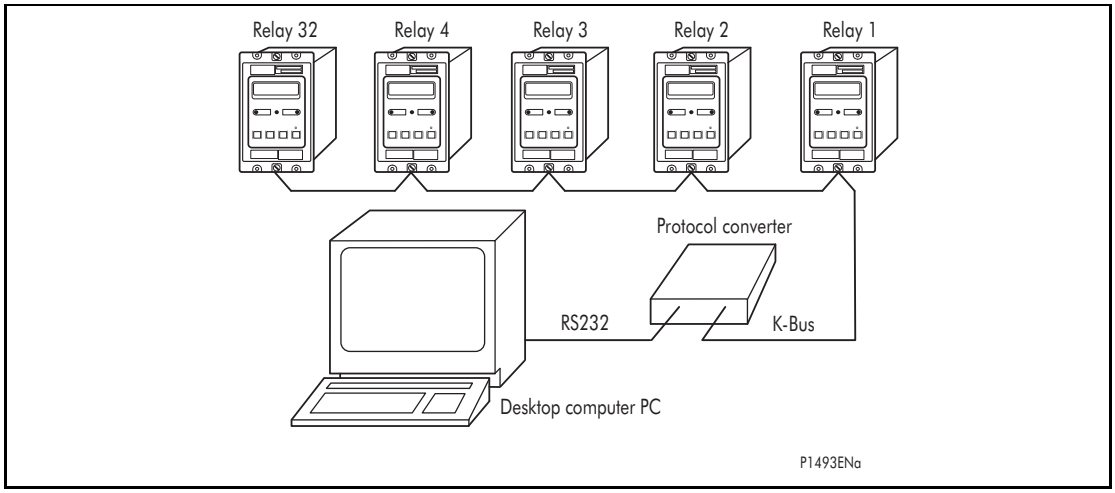


Figure 34: Basic communication system

7.2.2 K-Bus connections

Connection to the K-Bus Port is by standard Midos 4mm screw terminals or snap-on connectors. A twisted pair of wires is all that is required; the polarity of connection is not important. It is recommended that an outer screen is used with an earth connected to the screen at the Master Station end only. Termination of the screen is effected with the "U" shaped terminal supplied and which has to be secured with a self tapping screw in the hole in the terminal block just below terminal 56, as shown in the diagram. Operation has been tested up to 32 units connected along a 1,000 metres of cable. The specification for suitable cable will be found in the technical data Chapter. The method of encoding the data results in the polarity of the connection to the bus wiring being unimportant.

Note: K-Bus must be terminated with a 150Ω resistor at each end of the bus. The master station can be located at any position, but the bus should only be driven from one unit at a time.

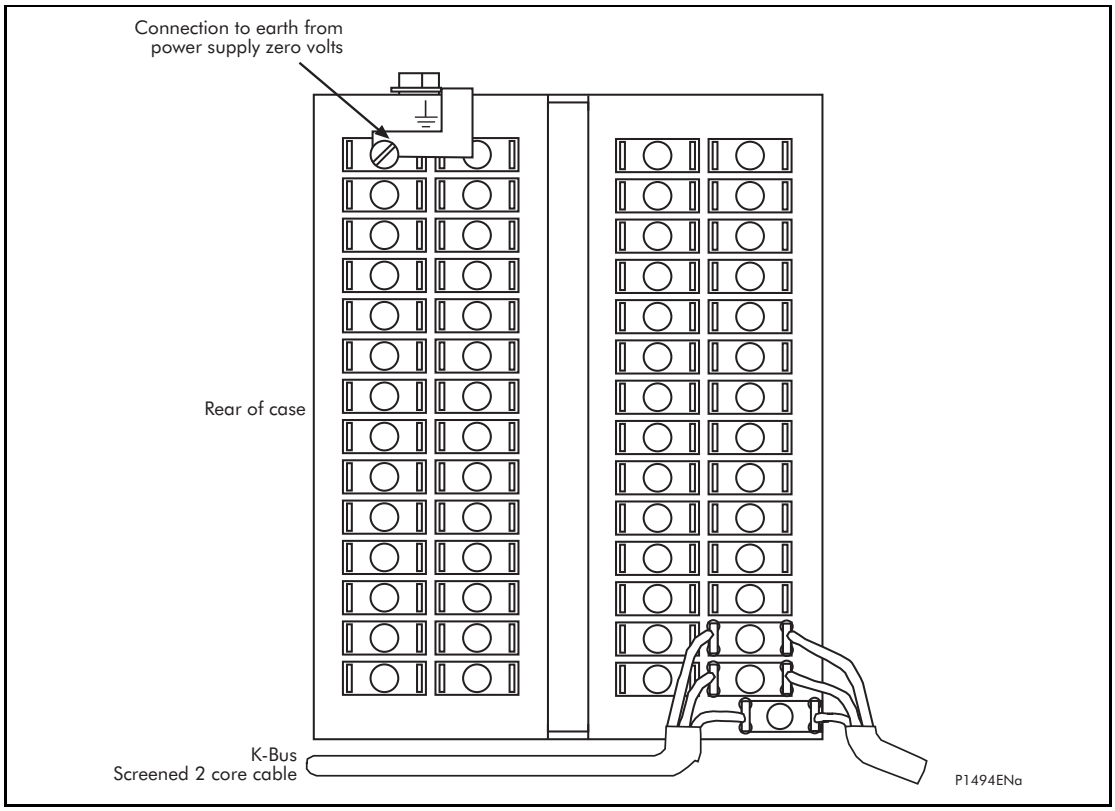


Figure 35: K-Bus connection diagram

7.2.3 Ancillary equipment

The minimum requirement to communicate with the relay is a K-Bus/IEC 60870-5 converter box type KITZ and suitable software to run on an IBM or compatible personal computer.

RS232 interconnection lead for connecting the KITZ to a personal computer (PC) and software as described in Chapter 7.3.

7.3 Software support

7.3.1 Courier Access

The Courier Access program is supplied with each KITZ and it allows on-line access to any relay or other slave device on the system. It polls all available addresses on the bus to build a list of the active relays. Each relay can be programmed with a product description (16 characters) and a plant reference (16 characters).

A particular relay may then be chosen and accessed to display a table listing the menu column headings. Selecting a heading from the list and pressing the return key of the computer returns the full page of data that has been selected.

Selecting a setting from the displayed page and pressing the return key again will bring up the setting change box displaying the current setting value and the maximum and minimum limits of setting that have been extracted from the relay. A new setting may be typed in and entered. The new value will be sent to the relay and the relay will send back a copy of the data it received. If the returned value matches what was sent, it is judged to have been received correctly and the display asks for confirmation that the new setting is to be entered. When the execution command is issued the relay checks the setting is within limits, stores it, then replies to state(s) if the new value has been accepted, or rejected.

If the setting selected is password protected, the relay will reply that access is denied. Any data received in error is automatically resent, any data not understood, but received without error is ignored. Thus setting changes by this route are secure.

A complete setting file can be extracted from the relay and stored on disc and printed out for record purposes. The stored settings can also be copied to other relays.

Control commands, such as load shedding/boosting, are actioned in the same way as setting changes and can be achieved with this program by using the setting change mechanism. This program supports modem connection but it cannot extract event or disturbance records.

7.3.2 PAS&T

The Protection Access Software and Toolkit (PAS&T) program performs all the functions described for the Access program, but additionally it can perform the following functions:

Automatically extracts event records, displays them on screen, prints, or stores them to disc.

Polls the relay for selected data at set intervals and displays the values on screen, or stores a selected number of values that it can plot on screen to show trend information.

Displays coded or decoded messages on screen to help de-bug the communication system.

The Auto-addressing feature allocates the next available address on the bus to a new relay.

7.3.3 CourierCom

CourierCom is a windows based setting program that can be used off-line, i.e. without the relays being connected. Setting files can be generated in the office and taken to site on floppy disc for loading to the relays. This program can be used to down-load the settings to the relay, alternatively ACCESS or PAS&T may be used.

7.3.4 PC requirements

To operate fully, the above programs require:

- IBM PC/XT/AT/PS2 or true compatible
- 640 kBytes of main memory RAM

- Graphics adapter CGA, EGA, VGA or MDA
- Serial adapter port configured as COM1 or COM2 (RS232)
- Floppy disc drive 3.5 inch
- MS-DOS 3.2 or later/IBM PC-DOS 3.2 or later
- Parallel printer port for optional printer
- Additional equipment
- Printer
- RS-232 link
- KITZ 101/KITZ 102/KITZ 201 K-Bus/RS232 communication interface
- Modem

7.3.5 Modem requirements

ALSTOM Grid SAS have adopted the IEC 60870-5 ft1.2 frame format for transmitting the courier communication language over RS-232 based systems, which includes transmission over modems.

The IEC 60870-5 ft1.2 specification calls for an 11-bit frame format consisting of 1 start bit, 8 data bits, 1 even parity bit and 1 stop bit.` However, most modems cannot support this 11-bit frame format, so a relaxed 10-bit frame format is supported by the Protection Access Software & Toolkit and by the KITZ, consisting of 1 start bit 8 data bits, no parity and 1 stop bit.

Although Courier and IEC-870 both have inherent error detection, the parity checking on each individual character in the 11-bit frame provides additional security and is a requirement of IEC 60870 in order to meet the error rate levels it guarantees. It is therefore recommended that modems should be used which support these 11-bit frames.

The following modems have been evaluated for use with the full IEC 60870 ft1.2 protocol and are recommended for use:

Dowty Quattro (SB2422)

Motorola Codex 3265 or 3265 Fast

Other modems may be used provided that the following features are available; refer to the modem documentation for details on setting these features:

Support an 11 bit frame (1 start bit, 8 data bits, 1 even parity bit and 1 stop bit). This feature is not required if the 10-bit frame format is chosen.

Facility to disable all error correction, data compression, speed buffering or automatic speed changes.

It must be possible to save all the settings required to achieve a connection in non-volatile memory. This feature is only required for modems at the outstation end of the link.

Notes: 1. The V23 asymmetric data rate (1200/75bps) is not supported

2. Modems made by Hayes do not support 11 bit characters.

7.4 Data for system integration

7.4.1 Relay address

The relay can have any address from 1 to 254 inclusive. Address 255 is the global address that all relays, or other slave devices, respond to. The Courier protocol specifies that no reply shall be issued by a slave device in response to a global message. This is to prevent all devices responding and causing contention on the bus.

The relay is supplied with its address set to 255 to ensure that when connected to an operational network they will not have a conflicting address with another device that are

already operational. To make the new devices fully operational they must have their address set. The address can be changed manually by entering the password and changing the address by the setting change method via the user interface on the front of the relay.

Alternatively, if the software running on the PC supports “auto-addressing”, the relay address can be set to “0” and the auto-addressing feature of the PC software turned on. The relay will then be automatically set to the next available address on the bus. PAS&T software supports both these feature.

If the address is 255, or unknown, the device address can be changed by sending a new address, in a global message, to a device with a particular serial number. This method is useful for devices that are not provided with a user interface with which to read the or change the current address and is supported by both PAS&T, ACCESS and CourierCom.

7.4.2 Measured values

Any measured value can be extracted periodically by polling the relay. Measured values are stored in the menu locations under column heading MEASURE.

7.4.3 Status word

A status byte is contained in every reply from a slave device. This is returned by the relay at the start of every message to signal important data on which the Master Station may be designed to respond automatically.

The flags contained are:

Bit 0 – 1 = Not used

Bit 1 – 1 = Plant status word changed

Bit 2 – 1 = Control status word changed

Bit 3 – 1 = Relay busy, cannot complete reply in time

Bit 4 – 1 = Relay out of service

Bit 5 – 1 = Event record available for retrieval

Bit 6 – 1 = Alarm LED lit

Bit 7 – 1 = Control LED lit

Bits 6 and 7 are used to mimic the alarm and control indication on the frontplate of the slave devices. They cannot be used extract fault and alarm information from a slave device because they cannot be guaranteed to be set for a long enough period to be identified.

Bits 5 enable the master station to respond automatically and extract event records, if they are so programmed so to do.

7.4.4 Plant status word

The plant status word can be found in menu cell 000C. It is used to transport plant status information over the communication network. This feature is not used on KVGC202 relay.

7.4.5 Control status word

The control status word will be found in menu cell 000D. It is used to transfer control information from the slave device to the master control unit.

7.4.6 Logic input status word

The status of the logic control inputs can be observed by polling menu cell 0020, where the lowest 8 bits of the returned value indicates the status of each of the 8 logic inputs. No control actions are possible on this cell other than to read it.

7.4.7 Output relay status word

The status of the output relays can be observed by polling menu cell 0021, where the lowest 8 bits of the returned value indicates the status of each of the 8 output relays. No control actions are possible on this cell other than to read it.

7.4.8 Alarm indications

The status of the internal alarms produced by the relays self test routine can be observed by polling menu cell 0022, where the lowest 7 bits of the returned value indicates the status of each of the alarms. No control actions are possible on this cell except for bit 6 which can be set/reset, in order to test the watchdog relay.

7.4.9 Event records

An event may be a change of state of a control input or an output relay; it may be a setting that has been changed locally; control function that has performed its intended function. A total of 50 events may be stored in a buffer, each with an associated time tag. This time tag is the value of a timer counter that is incremented every 1 millisecond.

The event records can only be accessed via the serial communication port when the relay is connected to a suitable Master Station. When the relay is not connected to a Master Station the event records can still be extracted within certain limitations:

The event records can only be read via the serial communication port and a K-Bus/IEC 60870-5 Interface Unit will be required to enable the serial port to be connected to an IBM or compatible PC. Suitable software will be required to run on the PC so that the records can be extracted.

When the event buffer becomes full the oldest record is overwritten by the next event.

Records are deleted when the auxiliary supply to the relay is removed, to ensure that the buffer does not contain invalid data. Dual powered relays are most likely to be affected.

The time tag will be valid for 49 days assuming that the auxiliary supply has not been lost within that time. However, there may be an error of ±4.3s in every 24 hour period due to the accuracy limits of the crystal. This is not a problem when a Master Station is on line as the relays will usually be polled once every second or so.

The contents of the event record are documented in chapter 6, Chapter 6.2.

7.4.10 Notes on recorded times

As described in chapter 6, Chapter 6.2.2 the event records are appended with the value of a 1 millisecond counter and the current value of the counter is appended to the start of each reply form a relay. Thus it is possible to calculate how long ago the event took place and subtract this from the current value of the real time clock in the PC.

If transmission is to be over a modem there will be additional delays in the communication path. In which case the KITZ can be selected to append the real time at which the message was sent and this value can then be used in the conversion of the time tags. With this method of time tagging, the time tags for all relays on K-Bus will be accurate, relative to each other, regardless of the accuracy of the relay time clock.

See also chapter 6, Chapter 6.2.4 for additional information on time tagging accuracy.

7.5 Setting control

Control functions via a KVGC202 relay can be performed over the serial communication link. They include change of relay settings, change of setting groups, remote control of the operating modes.

Remote control is restricted to those functions that have been selected in the relays menu table and the selection cannot be changed without entering the password.

CRC and message length checks are used on each message received. No response is given for received messages with a detected error. The Master Station can be set to resend a command a set number of times if it does not receive a reply or receives a reply with a detected error.

Note: Control commands are generally performed by changing the value of a cell and are actioned by the setting change procedure, as described in Chapter 7.3.1, and have the same inherent security. No replies are permitted for global commands as this would cause contention on the bus; instead a double send is used for verification of the message by the relay for this type of command. Confirmation that a control command, or setting change, has been accepted is issued by the relay and an error message is returned when it is rejected.

The command to change setting group does not give an error message when the group 2 settings are disabled unless link SD3=0 to inhibit response to a remote setting group change commands.

7.5.1 Remote setting change

The relay will only respond to setting change commands via the serial port if link SD1=1. Setting SD1=0 inhibits all remote setting changes with the exception of the SD software links and the password entry. Thus, with link SD1=0, remote setting changes are password protected.

To change them, the password must be remotely entered and the function link SD function link SD1 set to “1” to enable remote setting changes. When all setting changes have been made set link SD1=0 to restore password protection to remote setting changes.

7.5.2 Remote control of setting group

The setting group selection is fully described in chapter 5, Chapter 5.2 including the remote control of this function. Group 2 must be activated before it can be selected by setting software link SD4=1. Set link SD3=1 to enable the relay to respond change setting group commands, via the serial port to select group 2 and set SD4=1 to inhibit this function.

If the remote setting changes have been selected to have password protection, as described in Chapter 7.5.1, then it can also be applied to the remote setting group selection as follows. Set link SD3=0 to inhibit remote setting changes, then set link SD1=1 to enable remote setting changes and set link CTL2=1. The group 2 settings will then be in operation and setting link SD1=0 will restore the password protection.

If conventional SCADA has an output relay assigned to select the alternative setting group then it may be used to energise a logic input assigned in the input mask [070A STG GRP 2]. In this case set link SD3=0.

7.6 Loadshedding/boosting control

7.6.1 Remote control of loadshedding/boosting

The KVGC202 relay responds to the loadshedding/boosting by level Courier commands. These commands are used to control the level of loadshedding/boosting of the KVGC202 relay. The relay retains the selected level until new command is received or an opto input is energised, which overrides the command over the serial port. The settings are stored by the relay when the relay is powered-down and restored again on power-up.

The relay will only respond to the commands via serial port if link SD2=1. Setting SD2=0 inhibits all remote commands over the serial port.

The following cell locations are allocated to store three levels of loadshedding/boosting in the CONTROL column of the menu system.

LEVELS	Cell Location
Level 1	030E
Level 2	030F
Level 3	0310

The following truth table then applies:

COURIER COMMAND	SELECT
Level 0	None
Level 1	Select level 1 setting
Level 2	Select level 2 setting
Level 3	Select level 3 setting

7.6.2 Local control of loadshedding/boosting

Local loadshedding/boosting control of the relay are via using the opto inputs assigned in input mask. The three levels can be selected by energising one of the three opto input channels as required by the user. If more than one opto inputs are energised at any one time then the relay acts on the setting nearest to 0.

For example if,

Level1 = 3 % and Level 2 = +9 %, then level 1 is selected OR

Level1 = 3 % and Level 2 = –3 % then level 2 is selected. The –ve setting has priority over the +ve setting if both values are equally nearest to 0.

The following cell locations are assigned in the input masks.

LEVELS	Cell Location
Level 1	0707
Level 2	0708
Level 3	0709

8. TECHNICAL DATA

8.1 Ratings

8.1.1 Inputs

AC current (In)	Rated (In) (A)	Continuous (xIn)	3 sec (xIn)	1 sec (A)
Auxiliary	1	3.2	30	100
	5	3.2	30	400

Voltage Input (Line)	Rated (Vn) (V)	Continuous (xVn)	10 sec (xVn)
	110	4	5.4

		Operative range		
Auxiliary voltage (Vx)	Rated voltage (V)	DC supply (V)	AC supply (V)	Crest (V)
Auxiliary powered	24 – 125	19 – 150	50 – 133	190
	48 – 250	33 – 300	87 – 265	380

Frequency (Fn)	Nominal rating (Hz)	Operative range (Hz)
Freq. tracking	50 or 60	45 – 65
Non-tracking	50	47 – 52.5
Non tracking	60	57 – 63

	Rating (Vdc)	Off state (Vdc)	On state (Vdc)
Logic inputs	50	≤12	≥35

8.2 Outputs

Field voltage 48V dc (current limited to 60mA)

8.3 Burdens

8.3.1 Current circuits

	Circulating	Line	Conditions
In = 1A	2.600	0.007	ohms at In
In = 1A	2.600	0.007	ohms at 30In
In = 5A	0.100	0.007	ohms at In
In = 5A	0.100	0.007	ohms at 30In

8.3.2 Reference voltage

Vn = 110V 0.02VA @ 110V phase/neutral

8.3.3 Auxiliary voltage

The burden on the auxiliary supply depends upon the number of output relays and control inputs energised.

DC supply 2.5 – 6.0W at Vx max with no output relays or logic inputs energized

4.0 – 8.0W at Vx max with 2 output relays & 2 logic inputs energized

5.5 – 12W at Vx max with all output relays & logic inputs energized

AC supply 6.0 – 12VA at Vx max with no output relays or logic inputs energized

6.0 – 14VA at Vx max with 2 output relays & 2 logic inputs energized

13 – 23VA at Vx max with all output relays & logic inputs energized

8.3.4 Opto-isolated inputs

DC supply 0.25W per input (50V 10ký)

8.4 Control function setting ranges

Setting	Symbols	Setting range	Step size
Regulated voltage	Vs	90 – 139V	0.1V
Deadband	dVs	±0.5 % to ±20 % of Vs	0.1%
Resistive line drop compensation	Vr	0 – 50V	1.0V
Reactive line drop compensation	Vxl	–50 – +50V	1.0V
Circulating current compensation	Vc	0 – 50V	1.0V
Load shedding/boosting		0 – ±10 % of Vs	1%
Total taps available	TapsAvail	1 – 30	1
Maximum tap position	TP>	1 – 40/ 1 – 30	1
Minimum tap position	TP<	1 – 30/ 1 – 30	1
Total number of tap changes	TotalOps>	1 – 10000	1
Tap changer operations	Ops/tP>	1 – 100	1
Time period	tP	0 – 24 hrs	1 hr
Intertap delay	tINTER	0 – 120 seconds	0.1s
Tap pulse duration	tPULSE	0.5 – 5 seconds	0.5s
Tap change indication time	tTapChange	1 – 3 seconds	0.1s

8.5 Time delay setting ranges

8.5.1 Inverse time delay

The general expression for the inverse time curve:

$$t = k + [\ (\text{initial time delay setting})\ x\ (1/N)\ ]$$

where k = 0.5 for initial time delay setting -20s

k = 0 for initial time delay setting >20s

N indicates % deviation from Vs in multiples of Vdb% and is calculated as:

$$N = \left\{ \frac{\frac{\{Vreg - Vs\}}{Vs} * 100}{dVs} \right\}$$

where Vreg = Voltage to be regulated (90 to 139V in step 0.1V)

Vs = Voltage setting

dVs = Dead band ((0.5% to (20% of Vs in step 0.1%)

8.5.2 Definite time delay

Setting	Symbols	Setting range	Step size
Initial time (definite)	tINIT	0 – 20 secs	1 sec
		20 – 300 secs	10 secs

8.6 Supervision function settings

Setting	Symbols	Setting range	Step size
Undervoltage blocking	V<<	60 – 130V	1.0V
Undervoltage detection	V<	80 – 130V	1.0V
Overvoltage detection	V>	105 – 160V	1.0V
Circulating current	I_C	0.02 – 0.5A (I_n = 1A)	0.01A
		0.1 – 2.5A (I_n = 5A)	0.05A
Load current	$I_{L>}$	0.5 – 2.0A (I_n = 1A)	
		2.50 – 10A (I_n = 5A)	0.05A
Load current	$I_{L<}$	0 – 1A (I_n = 1A)	
		0 – 5A (I_n = 5A)	0.1A
Excessive circulating current time delay	tI_C	0 – 180 seconds	10 secs
Alarm initiation time delay	tFAIL>	0 – 15 minutes	30 secs
Power factor angle	Angle	0 – 90 degrees	1 deg.

8.7 Transformer ratios

CT ratios	9999: 1	Default = 1: 1
VT ratios	9999: 1	Default = 1: 1

8.8 Measurement (displayed)

System voltage	(0 – 819) x VT ratio (low accuracy) (70 – 200) x VT ratio (high accuracy)	volts phase/phase
Load current	(1 – 30)I_n x CT ratio	amps
Circulating current	(0 – 0.64)I_n x CT ratio	amps
Power factor	0.00 – 1.00 (–1.00 for reverse current)	
Frequency	45 – 65 (or 0)	Hz

8.9 Accuracy

Reference conditions	
Ambient temperature	20°C
Frequency	50Hz or 60Hz (whichever is set)
Auxiliary voltage	24V to 125V dc 48V to 250V dc

8.9.1 Current

Overcurrent	Minimum operation ±5%

8.9.2 Time delays

Definite time	±0.5% + 15 to 35ms

Inverse	±10%

8.9.3 Directional

Operating boundary	0 – 180° accuracy ±3°
PU – DO differential	less than 3° (typically <1°)

8.9.4 Measurements

Measured voltage	±2% Vn (typical) ±0.3% Vn over the range 70 – 160V (typical)
Load current	±2% In (typical)
Circulating current	±5% In (typical) ±10% In at <100mA
Power factor	±5%
Frequency (45 – 65Hz)	±1% (typical)

8.10 Influencing quantities

8.10.1 Ambient temperature

Operative range	–25 to +55°C
Current settings	±1%
Voltage settings	±0.03% per °C
Operation times	±1%
Angle measurement	<2°

8.10.2 Frequency

With frequency tracking	
Operative range	46 to 65Hz
Current setting	±1%
Voltage settings	±1%
Operating times	±1%
Angle measurement	<1°
Without frequency tracking	
Reference range	47Hz to 51Hz or 57Hz to 61Hz
Operating times	±2%

8.10.3 Angle measurement <2°

Auxiliary supply	Nominal	Operative range
	24/125V	19 to 150V dc 50 to 133V ac
	48/250V	33 to 300V dc 87 to 265V ac
Current settings	±0.5%	
Voltage settings	±0.5%	
Operation times	±0.5%	
Angle measurement	±0.5°	

8.11 Opto-isolated inputs

Capture time	12.5 ±2.5ms at 50Hz 10.4 ±2.1ms at 60Hz
Release time	12.5 ±2.5ms at 50Hz 10.4 ±2.1ms at 60Hz
Minimum operating voltage	>35V dc
Maximum operating voltage	50Vdc
Input resistance	10kΩ (add 12kΩ for every additional 50V in excess of 50V)
Maximum series lead resistance	2kΩ for single input at 40V min. 1kΩ for 2 inputs in parallel at 40V min 0.5kΩ for 4 inputs in parallel at 40V min
Maximum ac induced loop voltage	50V rms (thermal limit)
Maximum capacitance coupled ac voltage	250V rms via 0.1µF

8.12 Output relays

Output relays 0 to 7

Type		1 make
Rating	Make	30A and carry for 0.2s
	Carry	5A continuous
	Break	DC – 50W resistive
		25W inductive (L/R = 0.04s)
		AC – 1250VA (maxima of 5A)
		Subject to a maxima of 5A and 300V

Watchdog

Type		1 make + 1 break
Rating	Make	10A and carry for 0.2s
	Carry	5A continuous
	Break	DC – 30W resistive
		DC – 15W inductive (L/R = 0.04s)
		AC – 1250VA (maxima of 5A)
		Subject to a maxima of 5A and 300V
Durability		>10,000 operations

8.13 Operation indicator

3 Light Emitting Diodes - internally powered.

16 character by 2 line Liquid Crystal Display (with backlight).

8.14 Communication port

Language	Courier
Transmission	Synchronous – RS485 voltage levels
Format	HDLC
Baud Rate	64k/bit per second
K-Bus Cable	Screened twisted pair
Length	1000m

Bus Loading 32 units (mulitdrop system)

8.15 Current transformer requirements

Relay and CT secondary rated	Nominal output class (VA)	Acuracy class	Accuracy limit factor (x rated current
1/5A	2.5	5P	5

8.16 High voltage withstand

8.16.1 Dielectric withstand IEC 255-5:1977

2.0kV rms for 1 minute between all terminals connected together and case earth except terminal 1.

2.0kV rms for 1 minute between terminals of independent circuits, including contact circuits.

1.0kV rms for 1 minute across open contacts of the watchdog relay.

ANSI/IEEE, C37.90: 1989 .

1.5kV rms for 1 minute across open contacts of output relays 0 to 7.

8.16.2 High voltage impulse IEC 60255-5:1977

5kV peak, 1.2/50µs, 0.5J between all terminals and all terminals of the same circuit (except output contacts).

5kV peak, 1.2/50µs, 0.5J between all independent circuits and all terminals connected together (except terminal 1) and case earth.

5kV peak, 1.2/50µs, 0.5J across terminals of the same circuit except output contacts.

8.16.3 Insulation resistance IEC 60255-5:1977

>100MΩ when measured at 500Vdc

8.17 Electrical environment

8.17.1 DC supply interruptions IEC 60255-11:1979

The relay shall withstand a 10ms interrupt without de-energising.

8.17.2 AC ripple on dc supply IEC 60255-11:1979

The relay shall withstand 12 % ac ripple.

8.17.3 High frequency disturbance IEC 60255-22-1:1988

Class III –2.5kV peak between independent circuits and case.

–1.0kV peak across terminals of the same circuit.

8.17.4 Fast transient IEC 60255-22-4:1992

Class IV –4kV, 2.5kHz applied to all inputs and outputs.

8.17.5 EMC compliance

89/336/EEC Compliance with the European Commission Directive on EMC is claimed via the Technical Construction File route.

EN50081-2: 1994 Generic Standards used to estsablish conformity.

EN50082-2: 1995

8.17.6 Electrostatic discharge test IEC 60255-22-2 :1996

Class 3 (8kV) – discharge in air with cover in place

Class 2 (4kV) – point contact discharge with cover removed (IEC 60801-2)

8.17.7 Radiated immunity IEC 60255-22-3:1989 and IEC 60801-3:1984

Class III – field strength 10V/m and exteded frequency range 20MHz - 1000MHz.

8.17.8 Conducted immunity ENV50141:1993

Level 3 – 10V rms 0.15MHz - 80MHz.

8.17.9 Radiated emissions EN55011:1991

Group 1 – class A limits (30MHz - 1000MHz).

8.17.10 Conducted emissions EN55011:1991

Group 1 – class A limits (0.15MHz - 30MHz).

8.18 ANSI/IEEE Specifications

8.18.1 Surge withstand capability

C37.90.1 – 1989

8.18.2 Radiated electromagnetic Interference

C37.90.2 – 1995

35V/m over the frequency range 25 to 1000MHz.

8.19 Environmental

8.19.1 Temperature IEC 60255-6:1988

Storage and transit –25°C to +70°C

Operating –25°C to +55°C

8.19.2 Humidity IEC 60068-2-3:1969

56 days at 93% relative humidity and 40°C

8.19.3 Enclosure protection IEC 60529:1989

IP50 (Dust protected)

8.20 Mechanical environment

8.20.1 Vibration IEC 60255-21-1:1988

Response Class 1, Endurance Class 1

8.20.2 Shock and bump IEC 60255-21 2:1988

Shock response Class 1, Shock withstand Class 1 and Bump Class 1

8.20.3 Seismic IEC 60255-21-3:1993

Class 1

8.20.4 Mechanical durability

10,000 operations minimum

8.21 Model numbers

Relay type:	K V G C	2 0 2	0 1	F		1	G	

Configuration:	
Standard	0 1
Case size:	
Size 6 MIDOS Flush Mounting	F
Auxiliary voltage:	
24/125V	2
48/250V	5
Operating voltage:	
110V ac/50 – 60Hz	1
C.T. Rating:	
5/1A (User selectable)	G
Language:	
English	E
French	F
German	G
Spanish	S

8.22 Frequency response

The operating criteria for each element have been chosen to suit the applications for which it is most likely to be used. Knowing how these elements respond under operating conditions will help to apply them effectively.

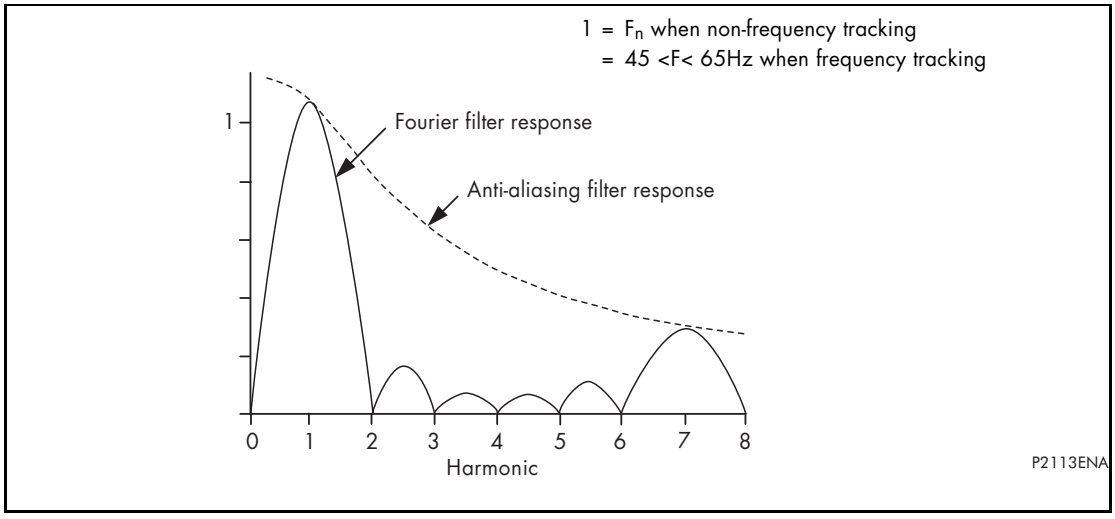


Figure 36: Response of Fourier filtering

Measurement is based on the Fourier derived value of the fundamental component of line (I_L), circulating current (I_c), Tap position indication voltage (VTPI) and low accuracy system voltage input (Vbc). The diagram above shows the frequency response that results from this filtering. The “1” on the horizontal scale relates to the selected rated frequency of the relay and the figures “2”, “3”, “4” etc. are the second, third and fourth harmonic frequencies respectively. It can be seen that harmonics up to and including the 6th are suppressed, giving no output. The 7th is the first predominant harmonic and this is attenuated to approximately 30% by the anti-aliasing filter. For power frequencies that are not equal to the selected rated frequency. i.e. the frequency does not coincide with “1” on the horizontal scale, the harmonics will not be of zero amplitude. For small frequency deviations of ±1Hz, this is not a problem but to allow for larger deviations, an improvement is obtained by the addition of frequency tracking.

With frequency tracking the sampling rate of the analogue/digital conversion is automatically adjusted to match the applied signal. In the absence of a signal of suitable amplitude to track, the sample rate defaults to that to suit the selected rated frequency (Fn) for the relay. In presence of a signal within the tracking range (45 to 65Hz), the relay will lock on to the signal and the “1” on the horizontal axis in diagram above will coincide with the measured frequency of the measured signal. The resulting output for 2nd, 3rd, 4th, 5th and 6th harmonics will be zero. Thus this diagram applies when the relay is not frequency tracking the signal and also if it is tracking a frequency within the range 45 to 65Hz.

9. COMMISSIONING, PROBLEM SOLVING AND MAINTENANCE

9.1 Commissioning preliminaries

The safety section should be read before commencing any work on the equipment.

When commissioning a KVGC202 relay for the first time, the engineers should allow an hour to get familiar with the menu. Please read Chapter 3 Section 3.3 which provides simple instructions for negotiating the relay menu using the push buttons [F] [+] [–] and [0] on the front of the relay. Individual cells can be viewed and the settable values can be changed by this method.

If a portable PC is available together with a K-Bus interface unit and the Courier Access software, then the menu can be viewed a page at a time to display a full column of data and text. Settings are also more easily entered and the final settings can be saved to a file on a disk for future reference or printing a permanent record. The instructions are provided with the Courier Access software.

9.1.1 Quick guide to local menu control

With the cover in place only the [F] and [0] push buttons are accessible, so data can only be read or flag and counter functions reset. No control or configuration settings can be changed. Refer to Chapter 3 Section 3.4.1 for a quick guide to the menu controls.

9.1.2 Terminal allocation

Reference should be made to the appropriate connection diagram shown elsewhere in this manual. Chapter 3 Section 3.5 gives further information on the external connections to the relay. Reference should also be made to the relay masks to identify which functions are allocated to which outputs.

9.1.3 Electrostatic discharge (ESD)

See recommendations in Chapter 2 of this user manual before handling module outside its case.

9.1.4 Inspection

Loosen the four cover screws and remove the cover, the relay can now be withdrawn from its case. Carefully examine the module and case to see that no damage has occurred since installation and visually check the current transformer shorting switches in the case are wired into the correct circuit and are closed when the module is withdrawn. Check that the serial number on the module, case and front plate are identical and that the model number and rating information are correct.

Check that the external wiring is correct to the relevant relay diagram or scheme diagram. The relay diagram number appears inside the case on a label at the left hand side. The serial number of the relay also appears on this label, and on the front plate of the relay module. The serial numbers marked on these two items should match; the only time that they may not match is when a failed relay module has been replaced for continuity of protection.

With the relay removed from its case, ensure that the shorting switches between terminals listed below are closed by checking with a continuity tester.

Terminals: 21 and 22; 23 and 24; 25 and 26; 27 and 28.

9.1.5 Earthing

Ensure that the case earthing connection, above the rear terminal block, is used to connect the relay to a local earth bar and where there is more than one relay the copper earth bar is in place connecting the earth terminals of each case in the same tier together.

9.1.6 Main current transformers

DO NOT OPEN CIRCUIT THE SECONDARY CIRCUIT OF A LIVE CT SINCE THE HIGH VOLTAGE PRODUCED MAY BE LETHAL TO PERSONNEL AND COULD DAMAGE INSULATION.

9.1.7 Test block

If the MMLG test block is provided, the connections should be checked to the scheme diagram, particularly that the supply connections are to the live side of the test block (coloured orange) and with the terminals allocated odd numbers (1, 3, 5, 7 etc.). The auxiliary supply is normally routed via terminals 13 (+) and 15 (–), but check against the schematic diagram for the installation.

9.1.8 Insulation

Insulation tests only need to be done when required.

Isolate all wiring from the earth and test the insulation with an electronic or brushless insulation tester at a dc voltage not exceeding 1000V. Terminals of the same circuits should be temporarily strapped together.

The main groups on the relays are given below but they may be modified by external connection as can be determined from the scheme diagram.

a) Current transformer circuits.

b) Voltage transformer circuits.

c) Auxiliary voltage supply.

d) Field voltage output and opto-isolated control inputs.

e) Relay contacts.

f) Communication port.

g) Case earth.

Note: Do not apply an insulation test between the auxiliary supply and the capacitor discharge terminals because they are part of the same circuit and internally connected.

9.2 Commissioning test notes

9.2.1 Equipment required

For KVGC202 relays the following equipment is required:

AC auxiliary supply suitable to supply a 30VA load. Frequency of 50/60Hz.

Multi-finger test plug type MMLB01 for use with test block type MMLG.

Continuity tester.

Three phase voltage supply 440V.

440/110V star/star phase shifting transformer AC voltmeter 0 – 440V

DC voltmeter 0 – 250V

AC Voltmeter 0 to 440V range

AC multi-range ammeter

Suitable non-inductive potentiometer to adjust polarising voltage level.

Interval timer

Phase angle meter or transducer. If necessary suitable current shunt(s) for use with the phase angle meter.

A portable PC, with suitable software and a KITZ101 K-Bus/IEC 60870-5 interface unit will be useful but in no way essential to commissioning.

9.3 Auxiliary supply tests

9.3.1 Auxiliary supply

The relay can be operated from either an ac or a dc auxiliary supply but the incoming voltage must be within the operating range specified in Table 1.

Relay rating (V)	DC operating	AC operating	Maximum crest	
		range (V)	range (VAC)	voltage (V)
	24/125	19 – 150	50 – 133	190
	48/250	33 – 300	87 – 265	380

Table 1

CAUTION: The relay can withstand some ac ripple on a dc auxiliary supply. However, in all cases the peak value of the auxiliary supply must not exceed the maximum crest voltage. Do not energise the relay using the battery charger with the battery disconnected.

9.3.1.1 Energisation from auxiliary voltage supply

For secondary injection testing using the test block type MMLG, insert test plug type MMLB01 with CT shorting links fitted. t may be necessary to link across the front of the test plug to restore the auxiliary supply to the relay.

Isolate the relay contacts and insert the module. With the auxiliary supply disconnected from the relay use a continuity tester to monitor the state of the watchdog contacts as listed in Table 2.

Connect the auxiliary supply to the relay. The relay should power up with the lcd showing the default display and the centre green led being illuminated; this indicates the relay is healthy. The relay has a non-volatile memory which remembers the state (ON or OFF) of the led control indicator when the relay was last powered, and therefore the indicator may be illuminated. With a continuity checker, monitor the state of watchdog contacts as listed in Table 2.

Terminals	With relay de-energised	With relay energised
3 and 5	contact closed	contact open
4 and 6	contact open	contact closed

Table 2

9.3.1.2 Field voltage

The relay generates a field voltage that should be used to energise the opto-isolated inputs. With the relay energised, measure the field voltage across terminals 7 and 8. Terminal 7 should be positive with respect to terminal 8 and should be within the range specified in Table 3 when no load is connected.

Nominal dc rating (V)	Range (V)
48	45 – 60

Table 3

9.4 Settings

All relays will leave the factory with the recommended settings for the KVGC202 relay under normal operating conditions, set for operation at a system frequency of 50Hz (refer to Chapter 5 Section 5.3). If operation at 60Hz is required then this must be set as follows:

From ‘SYSTEMS DATA’ menu, press the ‘F’ key until ‘0009 Freq 50Hz’ appears on the lcd. Press the ‘+’ key until the display shows ‘0009 Freq 60Hz’. Then press the ‘F’ key once more followed by the ‘+’ key to confirm the change.

There are two setting groups available, this allows the user to set Group 1 to normal operating conditions while Group 2 can be set to cover abnormal operating conditions.

The factory settings can be changed to the customer settings by referring to the instructions detailed in Chapter 3 Section 3.4.

The commissioning engineer should be supplied with all the required settings for the relay. The settings should be entered into the relay via the front keypad or using a portable PC with a K-Bus connection. Some settings are password protected, in these cases the password will also be required.

9.4.1 Selective logic functions to be tested.

For the selective logic checks only the features that are to be used in the application should be tested. Relay settings must not be changed to enable other logic functions that are not being used to be tested. However to conduct some tests some of the settings may require adjustments. The commissioning engineer should ensure that after completing all tests that all required settings are set for the relay.

If an output relay is found to have failed, an alternative relay can be reallocated until such time as a replacement can be fitted. Refer to Chapter 3 Sections 3.4.13 & 3.4.14 for how to set logic and relay masks.

Selective logic functions	Test
Regulated Voltage setting V_S and Dead Band Setting dV_S	6.1
Load Shedding/Boosting	6.2
Integrated timer	6.3
Line drop compensation	6.4
Under Voltage Detector (V<)	7.1
Over Voltage Detector (V>)	7.2
Load Current Detector (I_L)	7.3
Under Voltage Blocking (V<<)	7.4
Circulating Current Detector (I_C)	7.5
RunAway Protection	7.6

Table 4

Selective logic features listed below require K-Bus remote commands and are not covered by the commissioning instructions:

- Remote setting change
- Remote group change
- Remote load shedding/Boosting control.

Note: The above accuracy limits make no allowance for instrument errors and possible poor waveform which may be experienced during commissioning.

9.5 Measurement checks

All measurements can be viewed from the [0200 MEASURE] menu heading on the LCD.

9.5.1 Current measurement

To test the relay current measurement functions inject a known level of current into each current input in turn and monitor the values in the [0200 MEASURE] menu.

9.5.2 Voltage measurement

To test the relay voltage measurement functions apply a known level of voltage across the system voltage input and monitor the values in the [0200 MEASURE] menu.

9.6 Control functions

Reference should be made to Appendix 3 for the application diagram used for the following tests. The relay should be commissioned with the settings calculated for the application.

9.6.1 Regulated Voltage setting V_S and Dead Band dV_S

The relay should be commissioned with the settings calculated for the application.

This test checks the function of the transformer tap change control. The relay continuously monitors the system voltage and compares it with the reference voltage Vs. If the regulated voltage moves outside the deadband limits the relay actuates the tap changer mechanism to 'Raise' or 'Lower' the voltage to bring it back within the set deadband limits after the initial set time has elapsed.

[Before making the following changes note the settings for: Initial time delay (tINIT), inter-tap delay (tINTER) setting, and Initial time characteristic.

Set the initial time delay (tINIT) and the inter-tap delay (tINTER) to 0 seconds for continuous tap change.

Set the definite/inverse time characteristic to 'definite time'].

Monitor 'Raise volts', 'Lower volts' and 'Blocked' relay contacts.

Energise the auxiliary voltage supply and check that 'Blocked' is displayed on the LCD and 'Blocked' relay contact is closed.

Apply the system voltage and adjust the voltage equivalent to the system voltage setting (Vs) to (terminals 17 and 18). The 'CONTROL' LED should extinguish, and the raise/lower volts relay contacts should become open.

Slowly increase the supply voltage and record the voltage (V_{HIGH}) at which the 'Lower volts' contacts closes. The 'CONTROL' LED should illuminate. Reduce the supply voltage until 'CONTROL' LED extinguishes again.

Slowly reduce the voltage further and record the voltage (V_{LOW}) at which the raise volts contacts 'Raise volts' closes. The 'CONTROL' LED should illuminate.

Using the values recorded for V_{HIGH} and V_{LOW}, calculate the regulated value Vreg and the actual deadband as follows:

$Vreg = (V_{HIGH} + V_{LOW})/2$ $dVs_{actual} = (V_{HIGH} – V_{LOW})$

The value of Vreg should be (Vs ±0.5%) and the deadband should (dVs ±0.5% of Vs).

[Restore all settings changed i.e. the initial time delay, the inter-tap delay, and the initial time characteristic.]

9.6.2 Load shedding/boosting

The relay should be commissioned with the settings calculated for the application only check for the settings levels used for this application.

The purpose of this test is to ensure that the level of load shedding function is working.

The system voltage setting (Vs) can be raised or lowered by means of load shedding option.

[Before making the following changes note the setting for: input masks, inter-tap delay (tINTER) setting.

Set the inter-tap delay (tINTER) to 0 seconds

For this test ensure that the input masks are set to operate the following opto inputs [0707, 0708, 0709 INPUT MASKS]:

For test 1 and 4 connect L0 OPTO (terminal 46) to switch S1.

For test 2 and 5 connect L1 OPTO (terminal 48) to switch S1.

For test 3 and 6 connect L2 OPTO (terminal 50) to switch S1.

Set the load shedding/boosting setting level 1 to –3%, level 2 to –6% level 3 to –9% [030E, 030F, 0310 CONTROL].

Apply voltage equivalent to the system voltage input setting value Vs to (terminals 17 and 18).

Close switch S1. The 'Lower volts' relay output contact should close.

Slowly reduce the system voltage and check the voltage at which the 'Lower volts' relay output contacts re-opens. The contacts should re-open at a voltage shown in Table 5 for test 1. Increase the system voltage to Vs the 'Lower volts' contacts should be closed. Open switch S1. Repeat this for test 2 and 3 (i.e. other load shedding levels if set).

Set the load shedding/boosting setting level 1 to +3%, level 2 to +6% level 3 to +9% [Cell Ref. 030E, 030F, 0310 CONTROL].

Close switch S1. The 'Lower volts' relay output contact should close.

Slowly increase the system voltage and check the voltage at which the 'Raise volts' relay output contacts re-opens. The contacts should re-open at a voltage shown in Table 5 for test 4. Decrease the system voltage to Vs the 'Raise volts' contacts should be closed. Open switch S1. Repeat this for test 5 and 6 (i.e. other load shedding levels if set).

[Restore all settings changed i.e. input masks, and inter-tap delay (tINTER) setting.]

	Load Shedding Setting			Measured Vs
TEST	L0	L1	L2	
1	–3%	0	0	97% of Vs
2	0	–6%	0	94% of Vs
3	0	0	–9%	91% of Vs
4	+ 3%	0	0	103% of Vs
5	0	+6%	0	106% of Vs
6	0	0	+ 9%	109% of Vs

Table 5

9.6.3 Integrated timer

9.6.3.1 Initial time delay

The relay should be commissioned with the settings calculated for the application.

9.6.3.2 Definite time delay

The time delay to the first tap change initiation (initial delay) commences when the voltage goes outside the deadband. When the voltage is within the deadband the timer will reset at the same rate as it operates. To test the initial delay timer it is necessary to reset the timer. This is accomplished by swinging the voltage through the deadband from the side opposite to that which it will go to when timing is initiated.

Check that the initial time delay characteristic is set to 'Definite' [0301 CONTROL].

[Before making the following changes note the settings for: initial time delay (tINIT), inter tap delay (tINTER).

Set the initial time delay (tINIT) to 30 seconds,

the inter tap time delay (tINTER) to 0 seconds.]

Set the timer to start from closing of switch S2 and stop on closing of the lower volts contact 'Lower volts'.

Close switch S2, adjust the applied voltage to 110% of Vs.

Open switch S2 and reduce the voltage to 90% of Vs using a decade resistance box and reset the timer. Close switch S2 and measure the initial time delay. The 'Lower volts' relay output contacts should close after the initial time has elapsed.

Measured time should lie between 29.85s and 30.15s (ie. tINIT ±0.5%) or 15ms to 35ms whichever is greater.

[Restore the following settings: initial time delay (tINIT), inter tap delay (tINTER)].

9.6.3.3 Inverse time delay

The time delay to the first tap change initiation (initial delay) commences when the voltage goes outside the deadband. When the voltage is within the deadband the timer will reset at the same rate it operates. To test the initial delay timer it is necessary to reset the timer. This is accomplished by swinging the voltage through the deadband from the side opposite to that which it will go to when timing is initiated.

For this test the initial time delay is dependant on several factors; how far away the voltage deviates beyond the dead band edges, dead band setting and initial time delay setting.

The general expression for inverse time curve:

t = k + [(initial time delay setting) x (1/N)]

where

k = 0.5 for initial time delay setting -20s

= 0 for initial time delay setting >20s

N indicates % deviation from Vs in multiples of dVs% and is calculated as:

$$N = \left\{ \frac{\frac{\{Vbc - Vs\}}{Vs} * 100}{dVs\%} \right\}$$

where Vbc = Voltage to be regulated

Vs = Voltage setting

dVs = Dead band

Calculate the value of N

When Vbc = 105%Vs

Calculate the expected time t

When k = 0

Check that the initial time delay characteristic is set to 'Inverse' [0301 CONTROL].

[Before making the following changes note the settings: dVs, and initial time delay (tINIT)

Set dVs to 1%, and the initial time delay (tINIT) to 30 seconds.

Therefore N = 5 and t = 6 seconds]

Set the timer to start from closing of switch S2 and stop on closing of the lower volts contact 'Lower volts'.

Close switch S2, adjust the applied voltage to 105% of Vs.

The system voltage (Vs). Reset the timer.

Open switch S2 and adjust the voltage to 100% of Vs using a decade resistance box and reset the timer. Close switch S2 and measure the initial time delay. The ‘Lower volts’ relay output contacts should close after the initial time has elapsed.

Measured time should lie between 5.4s and 6.6s (i.e. tINIT ±10%).

[Restore the following settings: dVs, and initial time delay (tINIT).]

9.6.3.4 Inter-tap delay

The relay should be commissioned with the settings calculated for the application.

If the voltage is not back within the deadband limits after the first tap change, then additional tap changes will be initiated until the voltage level lies within the deadband limits.

[Before making the following changes note the settings for: intertap delay (tINTER), and deadband setting (dVs).

Set the intertap delay (tINTER) to 5 seconds and deadband setting (dVs) to 1%.]

Connect the timer to start from opening of the 'Lower volts' contact and stop on the closing of the 'Lower volts' contact.

Apply 105% of Vs to the system voltage input (terminals 17 & 18).

Close switch S2 and wait for relay to give a tap change signal. Whilst a tap change pulse is being given i.e. 'CONTROL' LED on the front of the relay is illuminated, reset the timer.

The timer will measure the inter tap time which runs from the instant the 'CONTROL' LED extinguishes to the instant the 'CONTROL' LED illuminates again.

Check that the measured inter-tap time is within 4.975 seconds to 5.025 seconds (i.e. tINTER ±0.5%).

Set the inter-tap setting to 0 seconds. Check the output is continuous, the 'CONTROL' LED should be continuously illuminated.

[Restore the following settings: intertap delay (tINTER), and deadband setting (dVs)].

9.6.4 Line drop compensation

9.6.4.1 Resistive load current compensation (Vr)

The relay should be commissioned with the settings calculated for the application.

Check the relay mode setting [0102 STATUS].

[Before making the following changes note the settings for: intertap delay (tINTER), system voltage (Vs), circulating compensation voltage (Vc), resistive line drop compensation setting (Vr), reactive line drop compensation setting (Vx), load current setting (I_L)].

Set the:

- intertap delay (tINTER) to 0 seconds,
- system voltage (Vs) setting to 100V,
- circulating compensation voltage (Vc) setting to 0V,
- resistive line drop compensation setting (Vr) to required setting (or 10V),
- reactive line drop compensation setting (Vx) to 0V,
- load current setting (I_L) to 1I_n],

Apply a current of 1 x I_n to the load current inputs (terminals 27 & 28). Apply the system voltage and adjust the phase angle until the current leads the voltage by 90 degrees.

A tap change should be initiated (i.e. Raise or Lower volts). Alter the system voltage (Vbc) until the relay stops tapping (i.e. both Raise and Lower volt contacts are open). Determine the regulated system voltage Vreg read [0202 MEASURE]. Check the value of Vr recorded as:

Vr = Vph – ph - Vreg ±0.5V or ±5% whichever is higher.

The measured line voltage Vph – ph can be read [0201 MEASURE]

Remove the load current from the relay.

If Vreg is lower than Vs it is almost certain that there is an unintentional polarity reversal somewhere in the test circuit.

[Restore the following settings:

- intertap delay (tINTER) ,
- system voltage input setting (Vs),
- circulating compensation voltage setting(Vc),
- resistive line drop compensation setting (Vr),
- reactive line drop compensation setting (Vx),
- load current setting (I_L)].

9.6.4.2 Reactive load current compensation (Vx)

The relay should be commissioned with the settings calculated for the application.

Check the relay mode setting [0102 STATUS].

[Before making the following changes note the settings and system data links for: intertap delay (tINTER), system voltage (Vs), circulating compensation voltage (Vc), resistive line drop compensation setting (Vr), reactive line drop compensation setting (Vx), load current setting (I_L)].

Set the:

- system voltage (Vs) setting to 100V,
- intertap delay (tINTER) to 0 seconds,
- circulating compensation voltage setting (Vc) to 0V,
- resistive line drop compensation setting (Vr) to 0V,
- reactive line drop compensation setting (Vx) to required setting (or 20V),
- load current setting (I_L) to 1I_n].

The reactive load drop compensation may be used to compensate for voltage drop due to reactive elements in the power line in the same way as the resistive load drop compensation. In addition, by setting the compensation to reverse compensation can be achieved for circulating currents as circulating currents have a high reactive content.

Apply a current of 1xI_n to the load current inputs, (terminals 27 and 28). Adjust the phase shifter to give 0 degree phase angle between the applied voltage and load current (voltage is in anti-phase with current).

A tap change should be initiated (i.e. Raise or Lower volts) and the ‘CONTROL LED’ should be illuminated. Alter the system voltage (Vbc) until the relay stop tapping (i.e. both Raise and Lower volt contacts are open). Determine the regulated system voltage Vreg [0202 MEASURE]. Check the value recorded is:

Vx = Vph – ph – Vreg ± 0.5V or ±5% whichever is greater.

The measured line voltage Vph – ph can be read in [0201 MEASURE]

Remove the load current from the relay.

[Restore the following settings and system data links:

- intertap delay (tINTER),
- system voltage input setting (Vs),
- circulating compensation voltage setting (Vc),
- resistive line drop compensation setting (Vr),

- reactive line drop compensation setting (Vx),
- load current setting (I_L)].

9.6.4.3 Circulating current compensation (Vc)

The relay should be commissioned with the settings calculated for the application.

The circulating current compensation is used when two or more transformers are paralleled. The circuits monitor the amount of current circulating between the transformers and applies a compensation voltage to cause the transformers to tap up or down as required to ensure the transformers are not more than 1 tap apart.

For the 1A rated relay.

Check the relay current rating is set to 1A [0304 CONTROL].

For the 5A rated relay.

Check the relay current rating is set to 5A [0304 CONTROL].

[Before making the following changes note the settings for: intertap delay (tINTER), system voltage (Vs), circulating compensation voltage (Vc), resistive line drop compensation setting (Vr), reactive line drop compensation setting (Vx), load current setting (I_L)].

Set the:

- intertap delay (tINTER) to 0 seconds,
- system voltage input setting (Vs) to 100V,
- circulating compensation voltage setting (Vc) to 10V,
- resistive line drop compensation setting (Vr) to 0V,
- reactive line drop compensation setting (Vx) to 0V,
- circulating current setting (I_c) to I_n].

9.6.4.4 Negative compensation

Apply 0.2I_n to the circulating current (I_c) inputs (terminals 23 & 24) (For the 5A rated relay use terminals 25 & 26). Adjust the phase shifter to give a 180 degree phase angle (negative I_c compensation) between the system voltage input and circulating current.

A tap change should be initiated (i.e. Raise or Lower volts) and the 'CONTROL LED' should be illuminated. Alter the system voltage (Vbc) until the relay stops tapping (i.e. both Raise and Lower volt contacts are open). Determine the regulated system voltage Vreg [0202 MEASURE]. Check the value recorded is: Vs +2V ±5%.

Remove the load current from the relay.

9.6.4.5 Positive compensation

Apply 0.2I_n to the circulating current (I_c) inputs (terminals 23 & 24) (For the 5A rated relay use terminals 25 & 26). Adjust the phase shifter to give a 0 degree phase angle (positive I_c compensation) between the system voltage input and circulating current.

A tap change should be initiated (i.e. Raise or Lower volts) and the 'CONTROL LED' should be illuminated. Alter the system voltage (Vbc) until the relay stops tapping (i.e. both Raise and Lower volt contacts are open). Determine the regulated system voltage Vreg [0202 MEASURE]. Check the value recorded is: Vs –2V ±5%.

Remove the load current from the relay.

[Restore the following settings and system data links:

- intertap delay (tINTER),

- system voltage input setting (Vs),
- circulating compensation voltage setting (Vc),
- resistive line drop compensation setting (Vr),
- reactive line drop compensation setting (Vx),
- load current setting (Ic)].

9.6.5 Negative reactance control (alternative method to circulating current compensation)

The relay should be commissioned with the settings calculated for the application.

Reverse reactance control is an alternative method to circulating current compensation.

This test verifies the operation (i.e. reversal of Vx vector) when used with line drop compensation. It also checks the operation of the load angle compensation on the V_R vector by determining regulation with various load angle settings (ANGLE).

[Before making the following changes note the settings and system data links for: SD1 link to 0, dead band setting dVs, intertap delay (tINTER), system voltage input setting (Vs), circulating compensation voltage setting (Vc), resistive line drop compensation setting (Vr), reactive line drop compensation setting (Vx), load current setting (IL)].

Set the:

- SD1 link to 0,
- dead band setting dVs to 1%
- intertap delay (tINTER) to 0 seconds,
- system voltage input setting (Vs) to 100V
- circulating compensation voltage setting (Vc) to 0V,
- resistive line drop compensation setting (Vr) to 10V,
- reactive line drop compensation setting (Vx) to 10V,
- load angle (ANGLE) of 40 degrees
- load current setting (IL) to 1In].

Apply 1A load current to terminals 27 & 28.

Apply 103.28V, adjust the phase angle until the current leads by 40 degrees. Check the relay regulates within this applied voltage ±1%. Check that the TAP is initiated outside the regulated voltage by increasing the input voltage and by monitoring the 'CONTROL' LED. The 'CONTROL' LED should illuminate for a period set by tPULSE when input voltage is increased to outside the regulated voltage.

[Restore the following settings and system data links:

- SD1 link to 0,
- dead band setting dVs,
- intertap delay (tINTER),
- system voltage input setting (Vs),
- circulating compensation voltage setting (Vc),
- resistive line drop compensation setting (Vr),
- reactive line drop compensation setting (Vx),
- load angle (ANGLE),

- load current setting (IL)].

9.7 Supervision and monitoring

9.7.1 Undervoltage detector (V<)

The relay should be commissioned with the settings calculated for the application.

The undervoltage detector blocks ‘Lower’ operations to prevent lower voltage on busbars local to the transformer.

[Before making the following changes note the settings for: initial time delay setting (tINIT), intertap delay (tINTER), undervoltage setting (V<).

Set the:

- initial time delay setting (tINIT) to 2 seconds,
- intertap delay (tINTER) to 0 seconds,
- undervoltage setting (V<) to 80V to 130V].

Set the relay output mask to operate undervoltage detector ‘V<‘, these contacts should be open. ‘Raise volts’ contacts should also be open.

Apply 95% of the system voltage setting to input (terminals 17 & 18). After the initial time delay, the ‘CONTROL’ LED should illuminate, the ‘Raise volts’ contacts should close, and the ‘Lower volts’ contacts should open.

Slowly reduce the applied voltage and measure the voltage at which the undervoltage relay contact ‘V<‘ closes.

Check the measured voltage is within (V<) –2% of setting.

Check the ‘Lower volts’ contacts remain open and ‘Raise volts’ contacts remain closed.

Increase the applied voltage above Vs setting and ensure ‘Lower volts’ contact closes and ‘Raise volts’ contact opens.

[Restore the following settings:

- initial time delay setting (tINIT),
- intertap delay (tINTER),
- undervoltage setting (V<)].

9.7.2 Overvoltage detector (V>)

The relay should be commissioned with the settings calculated for the application.

Operation of the overvoltage detector will block ‘Raise’ operations, to prevent excessive voltage on busbars local to the transformer.

Before making the following changes note the settings for: initial time delay setting (tINIT), intertap delay (tINTER), Overervoltage setting (V>).

Set the:

- initial time delay setting (tINIT) to 2 seconds,
- intertap delay (tINTER) to 0 seconds,
- overvoltage setting (V>) to 105V to 160V].

Set the relay output mask to operate over voltage detector ‘V>’ contacts. The contacts should be open.

Apply 105% of the system voltage settings to input (terminals 17 &18). After the initial time delay the, ‘CONTROL’ LED should illuminate. The ‘Lower volts’ contacts should close and the ‘Raise volts’ should open.

Slowly increase the applied voltage and measure the voltage at which the over voltage contact 'V>' closes.

Check the measured voltage is within (V>) +2% of setting.

Check the 'Raise volts' contacts remained open and the 'Lower volts' contacts remained closed

[Restore the following settings:

- initial time delay setting (tINIT),
- intertap delay (tINTER),
- undervoltage setting (V>)].

9.7.3 Overcurrent Detector (IL)

The relay should be commissioned with the settings calculated for the application.

This test will check if both the 'Raise' and 'Lower' operations of the relay are blocked by the operation of the internal relay when the load current IL exceeds the threshold setting if logic link LOG3 is set to '1'.

[Before making the following changes note the settings for: logic link LOG3, initial time delay setting (tINIT), intertrip delay (tINTER), load current (IL)].

Set the:

- logic link LOG3 to '0',
- initial time delay setting (tINIT) to 0 seconds,
- intertap delay (tINTER) to 0 seconds,
- load current (IL) to 0.5In].

Set the relay mask to operate 'IL>' and 'Blocked' relay output contacts. Both contacts should be open.

Connect a current source to load current input (terminals 27 & 28).

Apply voltage equivalent to the system voltage setting (Vs) to system voltage input terminals 17 & 18.

Slowly increase the load current from zero and measure the current at which the 'IL>' relay contact closes. The text on the LCD display should indicate excessive load current detected.

Check the measured current is in the range 0.475In to 0.525In (i.e. (IL) ±5%). Reduce the load current to zero.

Set logic link LOG3 to '1', to prevent tap change operation.

Slowly increase the load current from zero until the 'IL>' contact closes. The 'CONTROL' LED should now be lit permanently. The 'Blocked' relay contact should be closed and both 'Raise volts' and 'Lower volts' contacts should be open to indicate tap change.

Reduce the load current below the threshold setting, the 'IL>' and 'Blocked' relay contacts should open and the text 'IL>' on the LCD should clear. The 'CONTROL' LED should be extinguished.

[Restore the following settings:

- logic link LOG3,
- initial time delay setting (tINIT),

- intertap delay (tINTER),
- load current (I_L)].

9.7.4 Undervoltage blocking (V<<)

The relay should be commissioned with the settings calculated for the application.

When the system voltage input falls below set value, the undervoltage blocking detector operates and instantaneously resets the initial time delay thus inhibiting the relay outputs to 'Raise' or 'Lower' tap change operations.

Before making the following changes note the settings for: initial time delay setting (tINIT), intertap delay (tINTER), undervoltage blocking setting (V<<).

Set the:

- initial time delay setting (tINIT) to 10 seconds,
- intertap delay (tINTER) to 5 seconds,
- undervoltage blocking setting (V<<) 60V to 130V].

Set the relay output masks to operate undervoltage blocking contacts 'V<<' and undervoltage detector contacts 'V<'. Both contacts should be open.

Monitor 'Raise volts' should be open.

Apply 115% of system voltage to input (terminals 17 & 18).

The 'CONTROL' LED should illuminate and the 'Raise volts' relay contacts should close for a period of tPULSE. The undervoltage detector contacts 'V<' should be closed.

Slowly reduce the input voltage until the 'V<<' contacts closes simultaneously with the opening of the 'Raise volts' contacts. 'V<blk' should be displayed on the LCD.

Check the voltage at which the tap change is cancelled is in the range. (V<<) –5% of setting. Both 'Raise volts' and 'Lower volts' relay contacts should be open. The 'CONTROL LED' should be permanently lit and the 'Blocked' relay contacts should be closed.

Restore the following settings:

- initial time delay setting (tINIT),
- intertap delay (tINTER),
- undervoltage blocking setting (V<<)].

9.7.5 Circulating Current Detector (I_C)

The relay should be commissioned with the settings calculated for the application.

This test will check if both the 'Raise' and 'Lower' operations of the relay are internally blocked when the circulating current exceeds the set value if logic link LOG2 is set to '1'. This also causes an alarm output either instantaneously or with a definite time delay.

Set the relay mask to operate 'I_c>' and 'Blocked' relay output contacts. Both relay contacts should be open.

Before making the following changes note the settings for: logic link LOG2, initial time delay setting (tINIT), intertap relay (tINTER), circulating current setting (I_c), Excessive circulating current time delay (tI_c).

Set the:

- logic link LOG2 to '0',
- initial time delay setting (tINIT) to 0 seconds,
- intertap delay (tINTER) to 0 seconds,

- circulating current setting (Ic) 0.2 to 0.5A (1A) 0.1 to 2.5A (5A)
- the excessive circulating current time delay (tIC) to 0 seconds].

For the 1A rated relay.

Check the relay current rating is set to 1A [0304 CONTROL].

Connect a current source to the (1A) circulating current terminals 23 & 24 with terminals 25 & 26 open.

For the 5A rated relay.

Check the relay current rating is set to 5A [0304 CONTROL].

Connect a current source to the (5A) circulating current terminals 25 & 26 with terminals 23 & 24 open.

Set the relay mask to operate 'Ic>' and 'Blocked' relay output contacts. Both relay contacts should be open.

Slowly increase the circulating current from zero and measure the current at which the 'Ic>' relay contact closes. The text on the LCD display should indicate excessive circulating current detected.

Check the measured current is in the range Ic ±5%. Reduce the circulating current below the threshold setting and the 'Ic>' alarm should clear automatically along with the 'Ic>' text on the LCD.

Set the timer to start from application of circulating current and stop on closing of 'Ic>' relay contacts.

Set the excessive circulating current time delay setting (tIC) to 10 seconds. Set the circulating current (Ic) setting to 0.5In.

Apply 105% of Ic to terminals 23 & 24 (terminals 25 & 26 for the 5A relay) and measure the time. It should be 10 seconds ±5%. The 'Ic>' relay contact should be closed.

Reduce the circulating current to zero.

Set the logic link LOG2 to '1', the alarm condition will now also cause the blocking of the tap control operation.

Slowly increase the circulating current from zero and measure the current at which the 'Ic>' relay contact closes. The text on the LCD display should indicate excessive circulating current detected.

The 'Ic>' and 'Blocked' relay contacts should be closed. Both 'Raise volts' and 'Lower volts' contacts should be open.

Remove the current flowing into the circulating current detector.

[Restore the following settings:

- logic link LOG2,
- initial time delay setting (tINIT),
- intertap delay (tINTER),
- circulating current setting (Ic),
- the excessive circulating current time delay (tIC)].

9.7.6 RunAway protection

The relay should be commissioned with the settings calculated for the application.

This test checks the runaway protection feature which monitors the tap position to check if the tap changer operates in a direction which causes the voltage to move further away from the desired voltage (Vs) OR tap changer operates while the voltage is within the deadband (i.e. no tapping). Further tap changes are inhibited blocking tap change operation if LOG7 is set to '1' and initiate an alarm if runaway relay mask is set.

Check that the logic link LOG7 is set to '1' [0401 LOGIC].

[Before making the following changes note the settings for: initial time delay setting (tINIT), intertap delay (tINTER), the maximum tap position (TP>), minimum tap position (TP<)].

Set the:

- initial time delay setting (tINIT) to 10 seconds,
- intertap delay (tINTER) to 5 seconds,
- the maximum tap position (TP>) to 40 for VT TPI or to 30 for external voltage TPI
- minimum tap position (TP<) to 1].

Set the relay mask to operate 'RunAway' relay output contact. One of the default relay mask settings can be changed for 'RunAway'.

Connect a 100V ac source to tap position indication inputs (terminals 19 & 20).

Apply the system voltage setting value to the input (terminals 17 & 18).

Monitor 'Raise volts', 'Lower volts', 'RunAway' and 'Blocked' relay contacts, all should be open.

Apply 50V ac to the tap position indication inputs (terminals 19 & 20). Monitor the tap position by selecting measure column from the menu system on the LCD, it should be within the limits. Clear any conditions displayed on the relay LCD by pressing the [0] key.

Change the voltage on tap position indication inputs causing the tap changer to operate. Both 'Raise volts' and 'Lower volts' relay contacts should remain open. The 'Blocked' and 'RunAway' relay contacts should be closed.

Reset the relay to clear the RunAway alarm by depressing the [0] key. The 'CONTROL LED' should be extinguished. The 'Blocked' and 'RunAway' relay contacts should be open.

Decrease the system input voltage (Vs)causing the voltage to go outside the lower deadband . The 'CONTROL LED' and 'Raise volts' contact should operate for a period of tPULSE and 'Lower V' contacts should remain open.

Decrease voltage on tap position indication inputs causing the tap changer to lower the voltage instead of raising it. The 'CONTROL' LED should be permanently lit and the 'Raise volts and 'Lower volts' contacts should be open. The 'Blocked' and 'RunAway' relay contacts should be closed.

Increase the system input voltage to the Vs setting. Reset the relay to clear the RunAway alarm by depressing the [0] key. The 'CONTROL' LED should be extinguished. The 'Blocked' and 'RunAway' relay contacts should be open.

Increase the system input voltage. The 'CONTROL LED' and 'Lower volts' contact should operate for a period of tPULSE. The 'RunAway', 'Blocked' and 'Raise volts' contacts should be open.

Increase the voltage to tap position indication inputs causing the tap changer to operate to increase the voltage instead of lowering it. The 'CONTROL' LED should be lit permanently. The 'Raise volts' and 'Lower volts' relay contacts should be open. The 'Blocked' and 'RunAway' relay contacts should be closed.

Decrease the system input voltage to Vs. Reset the relay to clear the RunAway alarm by depressing the [0] key. The ‘CONTROL’ LED should be extinguished. The ‘Blocked’ and ‘RunAway’ relay contacts should be open.

Set the logic link LOG7 to ‘0’. Repeat the above tests and this time the RunAway function should not cause blocking of the ‘Raise volts’ or ‘Lower volts’ relay contacts. ‘RunAway’ relay contacts should operate as it did in the above tests.

[Restore the following settings:

- initial time delay setting (tINIT),
- intertap delay (tINTER),
- the maximum tap position (TP>),
- minimum tap position (TP<)].

9.7.7 Load Check

When the line drop compensation facility is used, check by applying a load down the line to prove that the polarities of the VT and CT are connected to the relay correctly. Large load current will provide a more conclusive result.

Calculate the expected voltage drops for both the Resistive and Reactive components in the line at the CT rated primary current and convert these to secondary valued using the VT ratio.

$$Vr = \left\{\frac{\sqrt{3} \times Ip \times R}{\text{VT ratio}}\right\} \qquad V_{XL} = \left\{\frac{\sqrt{3} \times Ip \times X_L}{\text{VT ratio}}\right\}$$

Where: Ip = primary rated current of line CT

R = resistive component of line impedance

X_L = reactive component of line impedance

VT ratio = ratio of primary to secondary voltages of line VT

[Before making the following changes note the settings for: Vr and V_X, deadband setting dVs, initial time delay setting (tINIT)].

Set the:

- Vr and V_X to the calculated values.
- deadband setting dVs to 3%,
- initial time delay setting (tINIT) to 0 seconds].

At the receiving end of the feeder measure the phase to phase voltage on the secondary of the VT. Repeat this at the feeding end on the same pair of lines.

Set Vs to the value measured at the receiving end. The relay should not cause tapping if all CT and VT connections are connected with the correct polarity. If tapping occurs then either CT and VT are not connected correctly or that the Vr and V_X settings do not match the line Vr, V_X.

Increase and decrease the Vs setting and record the settings at which the ‘Raise volts’ contacts and the ‘Lower volts’ contacts change state. If the average values of these two voltages are within 2% of the remote end value, then the relative connections to CT and VT are correct.

[Restore the following settings:

- Vr and V_X,
- deadband setting dVs,
- initial time delay setting (tINIT)].

Note: The commissioning engineer should ensure that after completing all tests that all required settings are set for the relay.

9.8 Problem solving

Should any of the relay‘s functions are found to be faulty it is recommended that the complete relay is returned to the ALSTOM Grid SAS factory or local service agency.

9.8.1 Password lost or not accepted

Relays are supplied with the password set to AAAA.

Only uppercase letters are accepted.

Password can be changed by the user, see Chapter 3, Chapter 3.4.7.

There is an additional unique recovery password associated with the relay which can be supplied by the factory, or service agent, if given details of its serial number.

The serial number will be found in the system data column of the menu and should correspond to the number on the label at the top right hand corner of the front plate of the relay. If they differ, quote the one in the system data column.

9.8.2 Software link settings

The following functions will not work unless appropriate links are set. These links apply to both group 1 and group 2. Password will need to be entered to set any links.

9.8.2.1 System links

Set function link [0003 SD Links] link 1 to ‘1’ to enable remote control.

Set function link [0003 SD Links] link 2 to ‘1’ to enable remote load shed/boost.

Set function link [0003 SD Links] link 3 to ‘1’ to enable remote change to group 2 setting.

Set function link [0003 SD Links] link 4 to ‘1’ to enable group 2 settings: 0=hidden.

Set function link [0003 SD Links] link 5 to ‘1’ to hold group 2 setting.

Set function link [0003 SD Links] link 6 to ‘1’ to enable reverse current to select group 2 setting.

Set function link [0003 SD Links] link 7 to ‘1’ to enable logic changes in event records.

Set function link [0003 SD Links] link 9 to ‘1’ to enable use of external TPI voltage supply.

9.8.2.2 Control links

For Group 1 settings:

Set function link [0301 CTL Links] link 1 to ‘1’ to select inverse time delay.

For Group 2 settings:

Group 2 CTL functional links are set in cell location [0501].

9.8.2.3 Logic links

For Group 1 settings:

Set function link [0401 LOG Links] link 1 to ‘1’ to block outside deadband for maximum time.

Set function link [0401 LOG Links] link 2 to ‘1’ to block for excessive circulating current.

Set function link [0401 LOG Links] link 3 to ‘1’ to block for excessive load current.

Set function link [0401 LOG Links] link 4 to ‘1’ to block for excessive number of operations.

Set function link [0401 LOG Links] link 5 to ‘1’ to block for frequent operation.

Set function link [0401 LOG Links] link 6 to ‘1’ to block operation for reverse current flow.

Set function link [0401 LOG Links] link 7 to ‘1’ to block for tap change runaway.

Set function link [0401 LOG Links] link 8 to ‘1’ to block for insufficient circulating current.

For Group 2 settings:

Group 2 LOG functional links are set in cell location [0601].

9.8.2.4 Second setting group not displayed or working

Set function link [0003 SD Links] link 5 to “1” to turn on the group 2 settings.

Set function links [0301 CTL1 and 0501 CTL2 Links] link 2 to ‘1’ to hold settings for group 2.

9.8.2.5 Software links cannot be changed

Enter the password as these menu cells are protected.

Links are not selectable if associated text is not displayed.

SD link 0009 cannot be selected if associated extra v.t. has not been fitted.

9.8.3 Alarms

If the watchdog relay operates, first check that the relay is energised from the auxiliary supply. If it is, then try to determine the cause of the problem by examining the alarm flags towards the bottom of the SYSTEM DATA column of the menu. This will not be possible if the display is not responding to key presses.

Having attempted to determine the cause of the alarm it may be possible to return the relay to an operable state by resetting it. To do this, remove the auxiliary power supply for approximately 10 seconds, possibly by withdrawing the module from its case. Then re-establish the supplies and the relay should in most cases return to an operating state.

Recheck the alarm status if the alarm led is still indicating an alarm state.

The following notes will give further guidance.

9.8.3.1 Watchdog alarm

The watchdog relay will pick up when the relay is operational to indicate a healthy state, with its “make” contact closed. When an alarm condition that requires some action to be taken is detected, the watchdog relay resets and its “break” contact will close to give an alarm.

Note: The green led will usually follow the operation of the watchdog relay.

There is no shorting contact across the case terminals connected to the “break” contact of the watchdog relay. Therefore, the indication for a failed/healthy relay will be cancelled when the relay is removed from its case.

If the relay is still functioning, the actual problem causing the alarm can be found from the alarm records in the SYSTEM DATA column of the menu (see Chapter 3, Chapter 3.3.5).

9.8.3.2 Unconfigured or uncalibrated alarm

For a CONFIGURATION alarm the control software is stopped and no longer performing its intended function. For an UNCALIBRATED alarm the control software will still be operational but there will be an error in its calibration that will require attention.

It may be left running provided the error does not cause any grading problems.

To return the relay to a serviceable state the initial factory configuration will have to be reloaded and the relay re-calibrated. It is recommended that the work be carried out at the factory, or entrusted to a recognised service centre.

9.8.3.3 Setting error alarm

A SETTING alarm indicates that the area of non-volatile memory where the selected control settings are stored, has been corrupted. The current settings should be checked against those applied at the commissioning stage or any later changes that have been made.

If a personal computer (PC) is used during commissioning then it is recommended that the final settings applied to the relay are copied to a floppy disc with the serial number of the relay used as the file name. The setting can then be readily loaded back into the relay if necessary, or to a replacement relay.

9.8.3.4 “No service” alarm

This alarm flag can only be observed when the relay is in the calibration or configuration mode when the tap control program will be stopped.

9.8.3.5 “No samples” alarm

This indicates that no samples are being taken. If this alarm flag is ever observed then it might be possible to reset the flag by removing the auxiliary supply to the relay for 10 seconds. The relay should be returned to the factory if this problem is not resolved.

9.8.3.6 “No Fourier” alarm

This indicates that fourier not performing. If this alarm flag is ever observed then it might be possible to reset the flag by removing the auxiliary supply to the relay for 10 seconds. The relay should be returned to the factory if this problem is not resolved.

9.8.4 Records

9.8.4.1 Problems with event records

A total of fifty events can be stored in a buffer. The oldest event is overwritten by the next event to be stored when the buffer becomes full.

The event records are erased if the auxiliary supply to the relay is lost for a period exceeding the hold-up time of the internal power supply.

Any change of state of a control input or output relay, local setting change or alarm conditions are stored in the relay.

Few events for change in state of logic inputs and relay outputs can be stored in the event records. The change in state of inputs and outputs can occur frequently to generate many events for each change in state occurrence. Setting System Data Link [SD7] to “0” will turn off this feature and allow the maximum number of event records to be stored.

Events can only be read via the serial communication port and not on the LCD.

Any spare opto-inputs may be used to log changes of state of external contacts in the event record buffer of the Relay. The opto-input does not have to be assigned to a particular function in order to achieve this.

When a master station has successfully read a record it usually clears it automatically and when all records have been read the event bit in the status byte is set to “0” to indicate that there are no longer any records to be retrieved.

9.8.5 Communications

Address cannot be automatically allocated if the remote change of setting has been inhibited by function link [0003 SD Links] link 1. This must be first set to “1”, alternatively the address must be entered manually via the user interface on the relay.

Address cannot be allocated automatically unless the address is first manually set to 0. This can also be achieved by a global command including the serial number of the relay.

Relay address set to 255, the global address for which no replies are permitted.

9.8.5.1 Measured values do not change

Values in the MEASURE column are snap-shots of the values at the time they were requested. To obtain a value that varies with the measured quantity it should be added to the poll list as described in R8514, the User Manual for the Protection Access Software & Tool kit.

9.8.5.2 Relay no longer responding

Check if other relays that are further along the bus are responding and if so, power down the relay for 10 seconds and then re-energise to reset the communication processor. This should not be necessary as the reset operation occurs automatically when the relay detects a loss of communication.

If relays further along the bus are not communicating, check to find out which are responding towards the master station. If some are responding then the position of the break in the bus can be determined by deduction. If none is responding then check for data on the bus or reset the communication port driving the bus with requests.

Check there are not two relays with the same address on the bus.

9.8.5.3 No response to remote control commands

Check that the relay is not inhibited from responding to remote commands by observing the system data function link settings. If so reset as necessary; a password will be required.

System data function links cannot be set over the communication link if the remote change of settings has been inhibited by setting system data function link [0003 SD Links] link 1 to “0”. Reset [0003 SD Links] link 1 to “1” manually via the user interface on the relay first.

Relay does not respond to load shedding/boosting levels set from the courier master station. Check input masks settings to ensure the load shedding/boosting is not selected by the opto inputs as this will override the commands over the serial port.

9.8.6 Output relays remain picked-up

Relays remain picked-up when de-selected by link or mask.

If an output relay is operated at the time it is de-selected, either by a software link change or by de-selecting it in an output mask, it may remain operated until the relay is powered down and up again. It is therefore advisable to momentarily remove the energising supply after such changes.

9.8.7 Measurement accuracy

The values measured by the relay can be compared with known system values to check that they are approximately within the tolerance given below. If they are not then the following can be tried:

- Reset the relay by removing the auxiliary supply for 10 seconds
- Recalibrate the relay

If problem is still not solved, then the relay should be returned to the factory.

The measurements should be within the following tolerance:

Measurements	Tolerance
Load current	±2%
Circulating current	±5%
Measured Voltage	±2%
Regulated Voltage	±0.5% of system voltage
Frequency	±1%
Timing measurements	±0.5% or 15 to 35ms (Definite time) ±10% (Inverse time)

9.9 Maintenance

K Range Midos relays are self-supervising and so require less maintenance. Most problems will result in an alarm so that remedial action can be taken. However, some periodic tests could be conducted to ensure that the relay is functioning correctly.

9.9.1 Preliminary checks

Loosen the four cover screws and remove the cover, the relay can now be withdrawn from its case. Carefully examine the module and case to see that no damage has occurred since installation and visually check the current transformer shorting switches in the case are wired into the correct circuit and are closed when the module is withdrawn. Check that the serial number on the module, case and front plate are identical and that the model number and rating information are correct.

Check that the external wiring is correct to the relevant relay diagram or scheme diagram. The relay diagram number appears inside the case on a label at the left hand side. The serial number of the relay also appears on this label, and on the front plate of the relay module. The serial numbers marked on these three items should match; the only time that they may not match is when a failed relay module has been replaced for continuity of protection.

With the relay removed from its case, ensure that the shorting switches between terminals listed below are closed by checking with a continuity tester.

Terminals: 21 and 22; 23 and 24; 25 and 26; 27 and 28.

9.9.1.1 Earthing

Ensure that the case earthing connection, above the rear terminal block, is used to connect the relay to a local earth bar and where there is more than one relay the copper earth bar is in place connecting the earth terminals of each case in the same tier together.

9.9.1.2 Main current transformers

DO NOT OPEN CIRCUIT THE SECONDARY CIRCUIT OF A LIVE CT SINCE THE HIGH VOLTAGE PRODUCED MAY BE LETHAL TO PERSONNEL AND COULD DAMAGE INSULATION.

9.9.2 Remote testing

The relay can be communicated with from a remote point, via its serial port, then some testing can be carried out without actually visiting the site.

9.9.2.1 Alarms

The alarm status led should first be checked to identify if any alarm conditions exist. The alarm records can then be read to identify the nature of any alarm that may exist.

9.9.2.2 Measurement accuracy

The values measured by the relay can be compared with known system values to check that they are in the approximate range that is expected. If they are, then the analogue/digital conversion and calculations are being performed correctly.

9.9.3 Local testing

When testing locally, similar tests may be carried out to check for correct functioning of the relay.

9.9.3.1 Alarms

The alarm status led should first be checked to identify if any alarm conditions exist. The alarm records can then be read to identify the nature of any alarm that may exist.

9.9.3.2 Measurement accuracy

The values measured by the relay can be checked against known values injected into the relay via the test block, if fitted, or injected directly into the relay terminals. Suitable test methods will be found in Section 8.1 of this manual which deals with commissioning. These tests will prove the calibration accuracy is being maintained.

9.9.3.3 Additional tests

Additional tests can be selected only from the features that are to be used in the application these features are listed in the Commissioning test instructions as required.

9.9.4 Method of repair

Please read the handling instructions in Section 1 before proceeding with this work. This will ensure that no further damage is caused by incorrect handling of the electronic components.

9.9.4.1 Replacing a pcb

a) Replacement of user interface

Withdraw the module from its case.

Remove the four screws that are placed one at each corner of the front plate.

Remove the front plate.

Lever the top edge of the user interface board forwards to unclip it from its mounting.

Then pull the pcb upwards to unplug it from the connector at its lower edge.

Replace with a new interface board and assemble in the reverse order.

b) Replacement of main processor board

This is the pcb at the extreme left of the module, when viewed from the front.

To replace this board:

First remove the screws holding the side screen in place. There are two screws through the top plate of the module and two more through the base plate.

Remove screen to expose the pcb.

Remove the two retaining screws, one at the top edge and the other directly below it on the lower edge of the pcb.

Separate the pcb from the sockets at the front edge of the board. Note that they are a tight fit and will require levering apart, taking care to ease the connectors apart gradually so as not to crack the front pcb card. The connectors are designed for ease of assembly in manufacture and not for continual disassembly of the unit.

Reassemble in the reverse of this sequence, making sure that the screen plate is replaced with all four screws securing it.

c) Replacement of auxiliary expansion board

This is the second board in from the left hand side of the module.

Remove the processor board as described above in b).

Remove the two securing screws that hold the auxiliary expansion board in place.

Unplug the pcb from the front bus as described for the processor board and withdraw.

Replace in the reverse of this sequence, making sure that the screen plate is replaced with all four screws securing it.

9.9.4.2 Replacing output relays and opto-isolators

PCBs are removed as described in Section 9.9.4.1 b and c. They are replaced in the reverse order. Calibration is not usually required when a pcb is replaced unless either of the two boards that plug directly on to the left hand terminal block are replaced, as these directly affect the calibration.

Note that this pcb is a through hole plated board and care must be taken not to damage it when removing a relay for replacement, otherwise solder may not flow through the hole and make a good connection to the tracks on the component side of the pcb.

9.9.4.3 Replacing the power supply board

Remove the two screws securing the right hand terminal block to the top plate of the module.

Remove the two screws securing the right hand terminal block to the bottom plate of the module.

Unplug the back plane from the power supply pcb.

Remove the securing screw at the top and bottom of the power supply board.

Withdraw the power supply board from the rear, unplugging it from the front bus.

Reassemble in the reverse of this sequence.

9.9.4.4 Replacing the back plane

Remove the two screws securing the right hand terminal block to the top plate of the module.

Remove the two screws securing the right hand terminal block to the bottom plate of the module.

Unplug the back plane from the power supply pcb.

Twist outwards and around to the side of the module.

Replace the pcb and terminal block assembly.

Reassemble in the reverse of this sequence.

9.9.5 Recalibration

Whilst recalibration is not usually necessary it is possible to carry it out on site, but it requires test equipment with suitable accuracy and a special calibration program to run on a PC. This work is not within the capabilities of most people and it is recommended that the work is carried out by an authorised agency.

After calibration the relay will need to have all the settings required for the application re-entered and so it is useful if a copy of the settings is available on a floppy disk. Although this is not essential it can reduce the down time of the system.

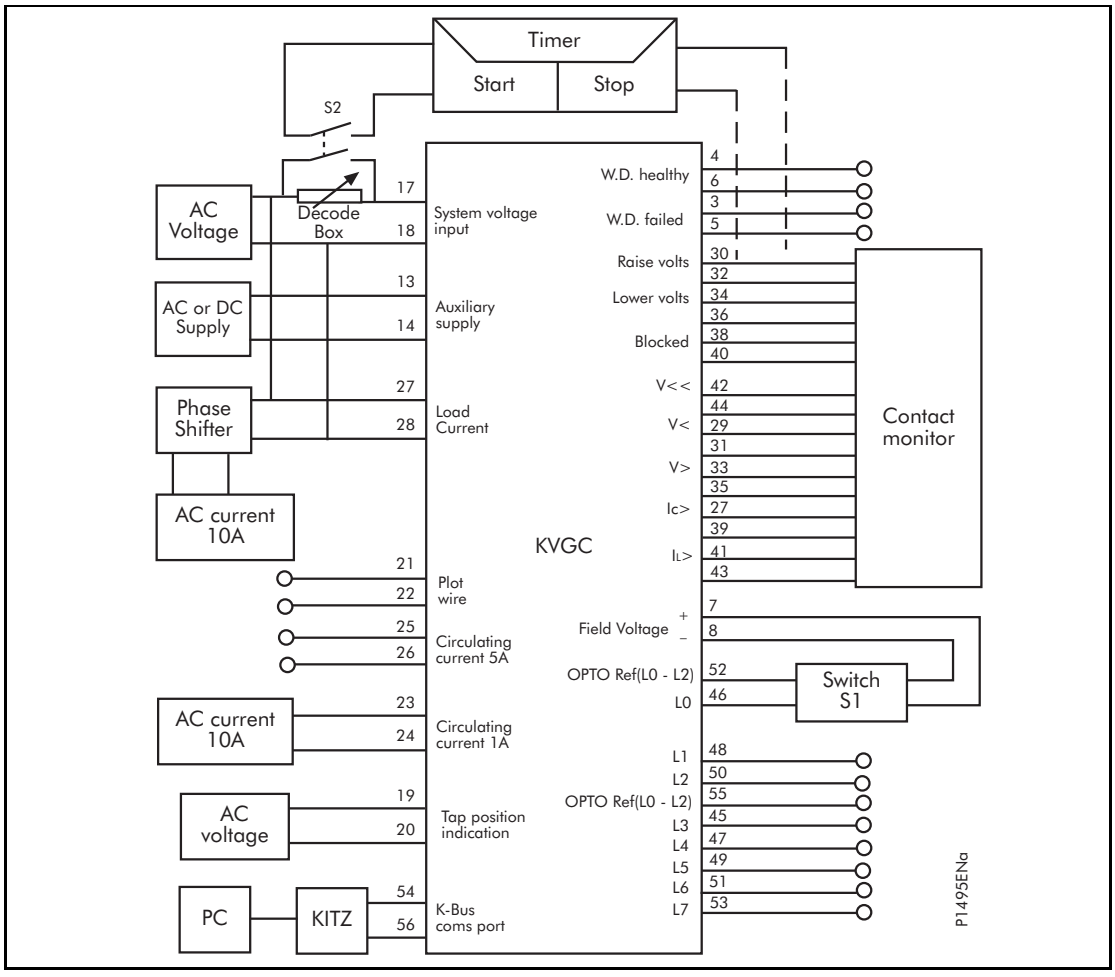


Figure 37: Test circuit diagram

APPENDIX 1

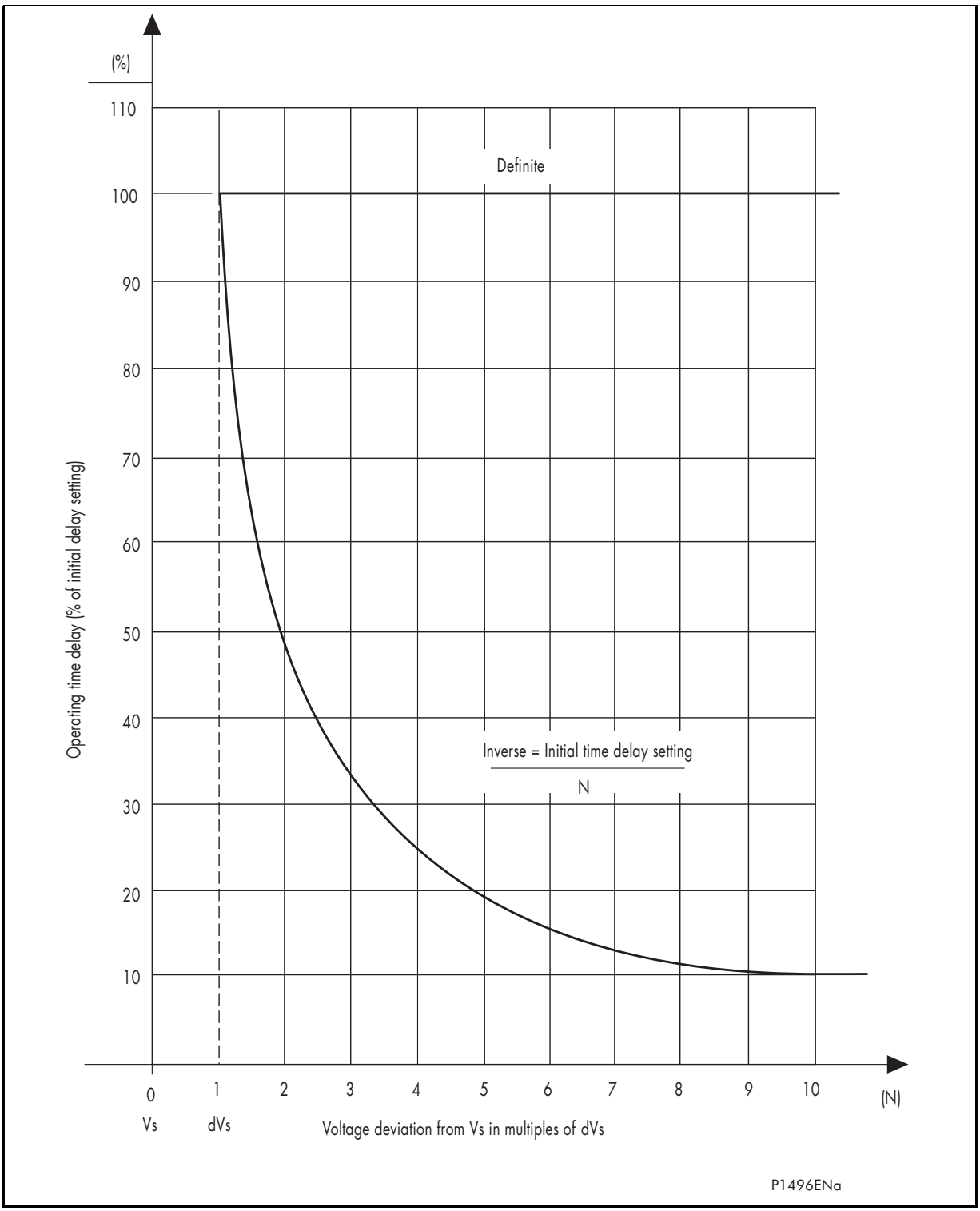
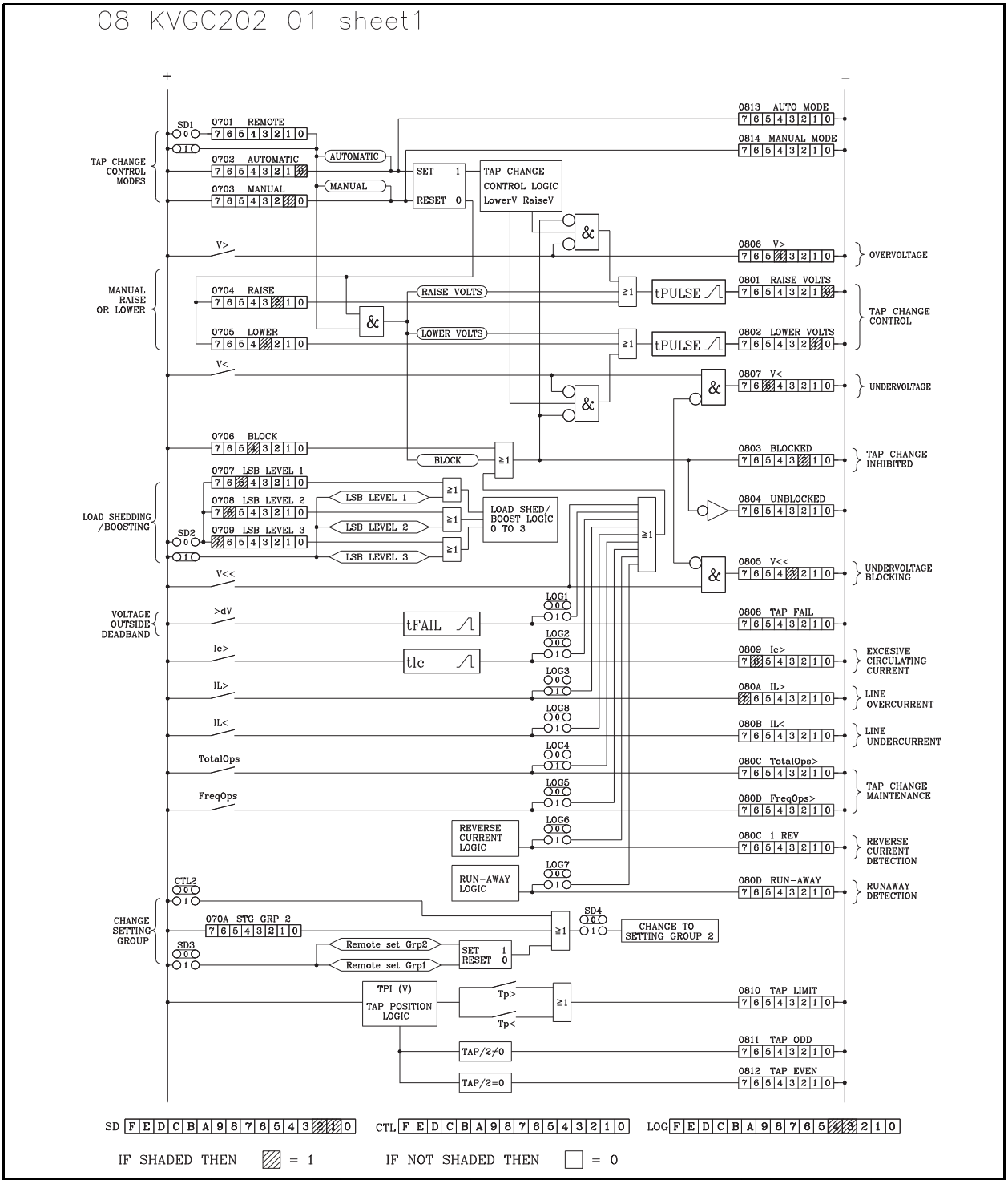
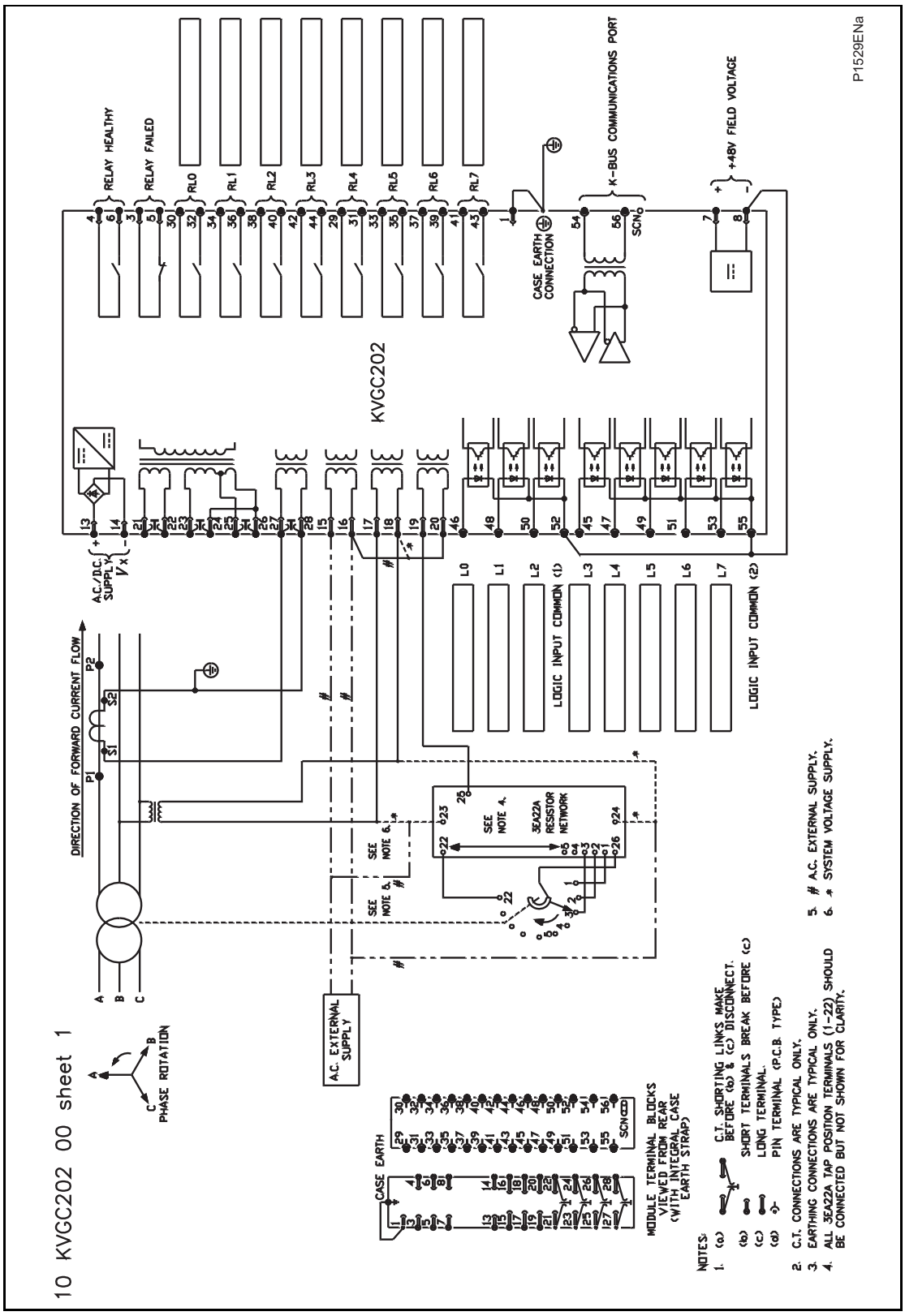


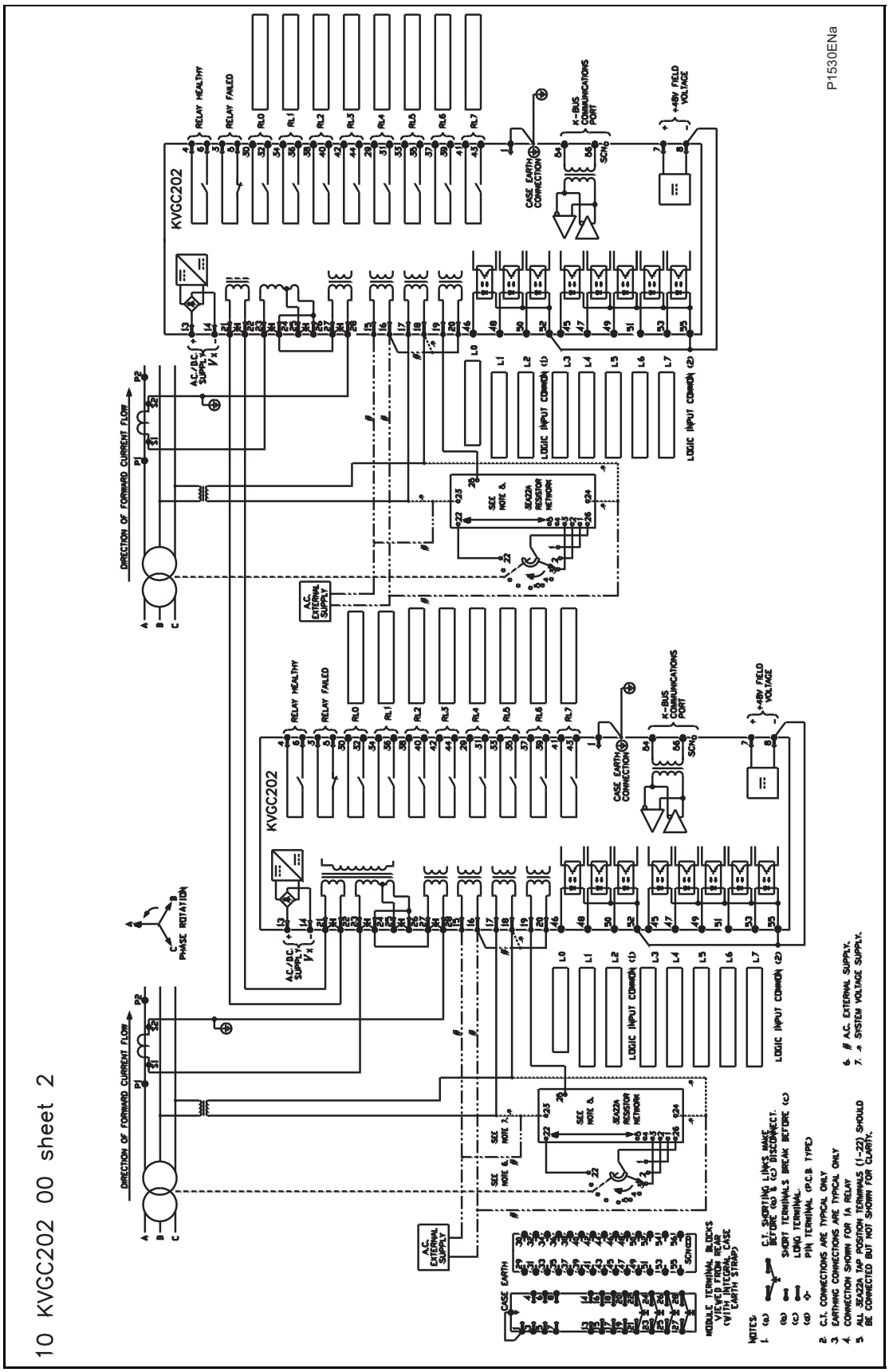
Figure 38: Relay inverse time characteristic curve

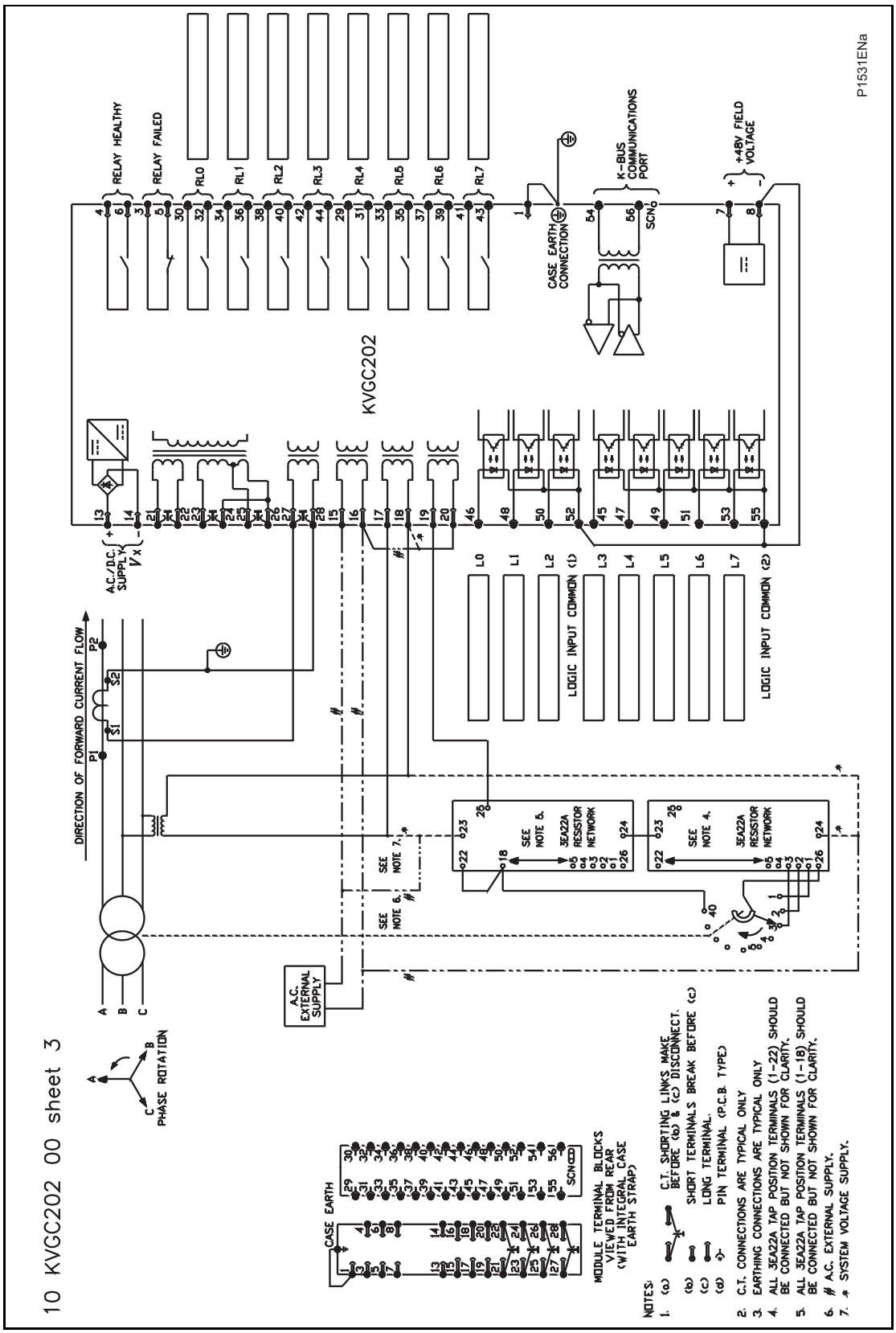
APPENDIX 2

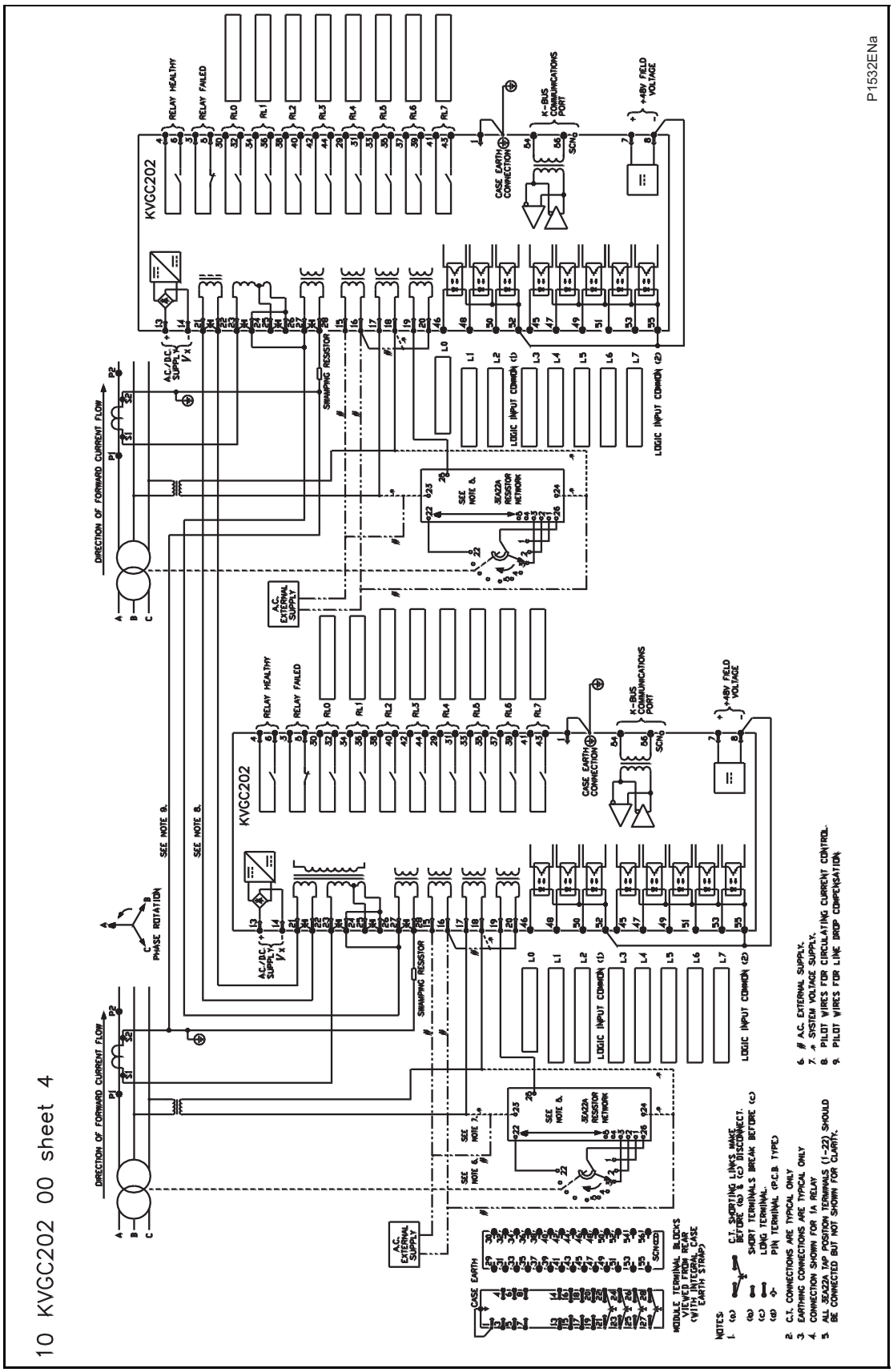

08 KVGC202 01 sheet1
+
−
TAP CHANGE CONTROL MODES
SD1
0701 REMOTE
0702 AUTOMATIC
0703 MANUAL
AUTOMATIC
MANUAL
SET 1
RESET 0
TAP CHANGE CONTROL LOGIC LowerV RaiseV
0813 AUTO MODE
0814 MANUAL MODE
V>
0806 V>
OVERVOLTAGE
MANUAL RAISE OR LOWER
0704 RAISE
0705 LOWER
RAISE VOLTS
LOWER VOLTS
≥1
tPULSE
0801 RAISE VOLTS
0802 LOWER VOLTS
TAP CHANGE CONTROL
V<
0807 V<
UNDERVOLTAGE
0706 BLOCK
BLOCK
0803 BLOCKED
TAP CHANGE INHIBITED
0804 UNBLOCKED
LOAD SHEDDING /BOOSTING
0707 LSB LEVEL 1
0708 LSB LEVEL 2
0709 LSB LEVEL 3
SD2
LSB LEVEL 1
LSB LEVEL 2
LSB LEVEL 3
LOAD SHED/ BOOST LOGIC 0 TO 3
V<<
0805 V<<
UNDERVOLTAGE BLOCKING
VOLTAGE OUTSIDE DEADBAND
>dV
tFAIL
LOG1
0808 TAP FAIL
Ic>
tIc
LOG2
0809 Ic>
EXCESIVE CIRCULATING CURRENT
IL>
LOG3
080A IL>
LINE OVERCURRENT
IL<
LOG8
080B IL<
LINE UNDERCURRENT
TotalOps
LOG4
080C TotalOps>
FreqOps
LOG5
080D FreqOps>
TAP CHANGE MAINTENANCE
REVERSE CURRENT LOGIC
LOG6
080C 1 REV
REVERSE CURRENT DETECTION
RUN-AWAY LOGIC
LOG7
080D RUN-AWAY
RUNAWAY DETECTION
CTL2
CHANGE SETTING GROUP
070A STG GRP 2
SD3
SD4
Remote set Grp2
Remote set Grp1
SET 1
RESET 0
CHANGE TO SETTING GROUP 2
TPI (V)
TAP POSITION LOGIC
Tp>
Tp<
0810 TAP LIMIT
TAP/2≠0
0811 TAP ODD
TAP/2=0
0812 TAP EVEN
SD F E D C B A 9 8 7 6 5 4 3 2 1 0
CTL F E D C B A 9 8 7 6 5 4 3 2 1 0
LOG F E D C B A 9 8 7 6 5 4 3 2 1 0
IF SHADED THEN = 1
IF NOT SHADED THEN = 0

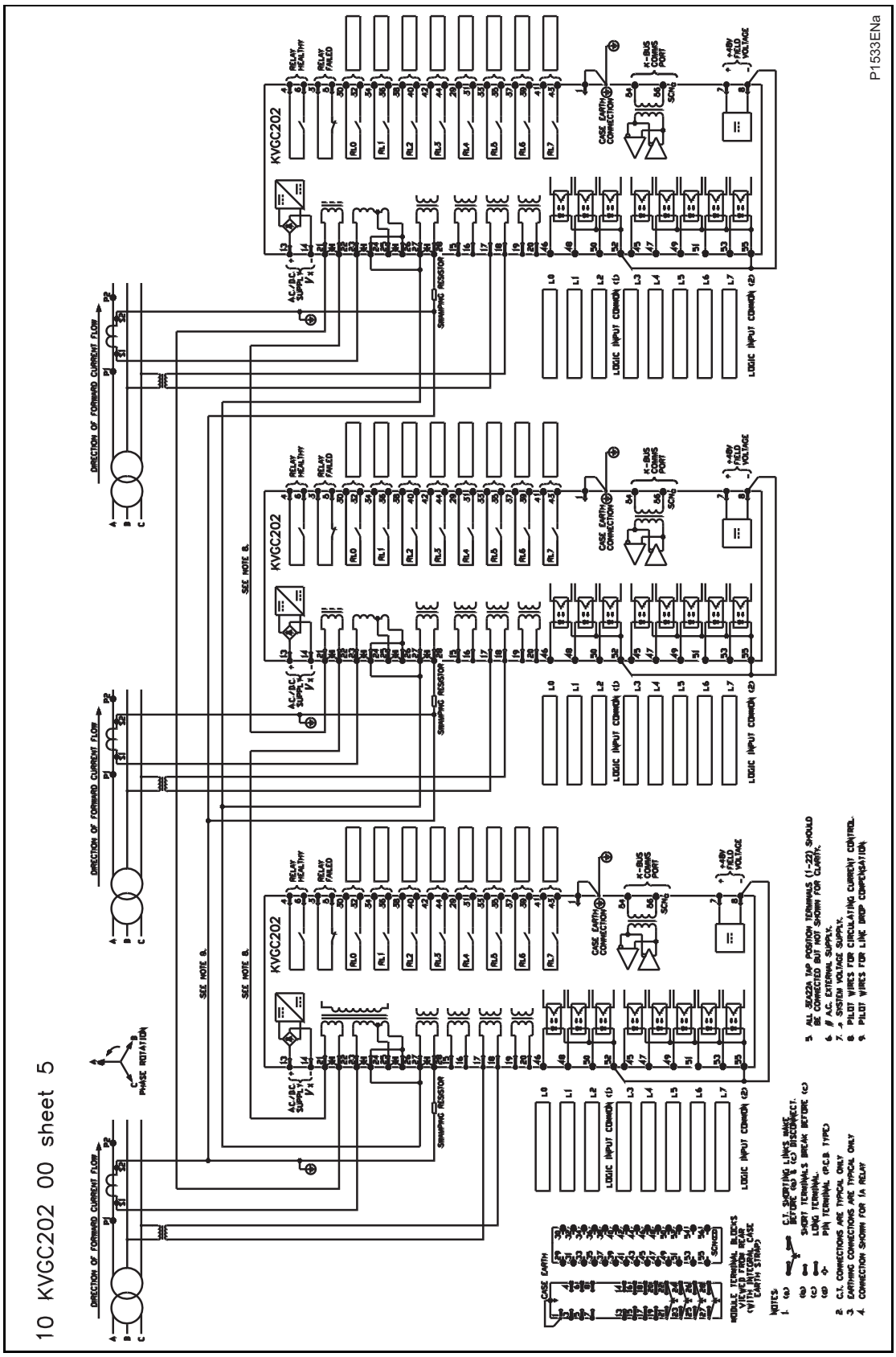
APPENDIX 3

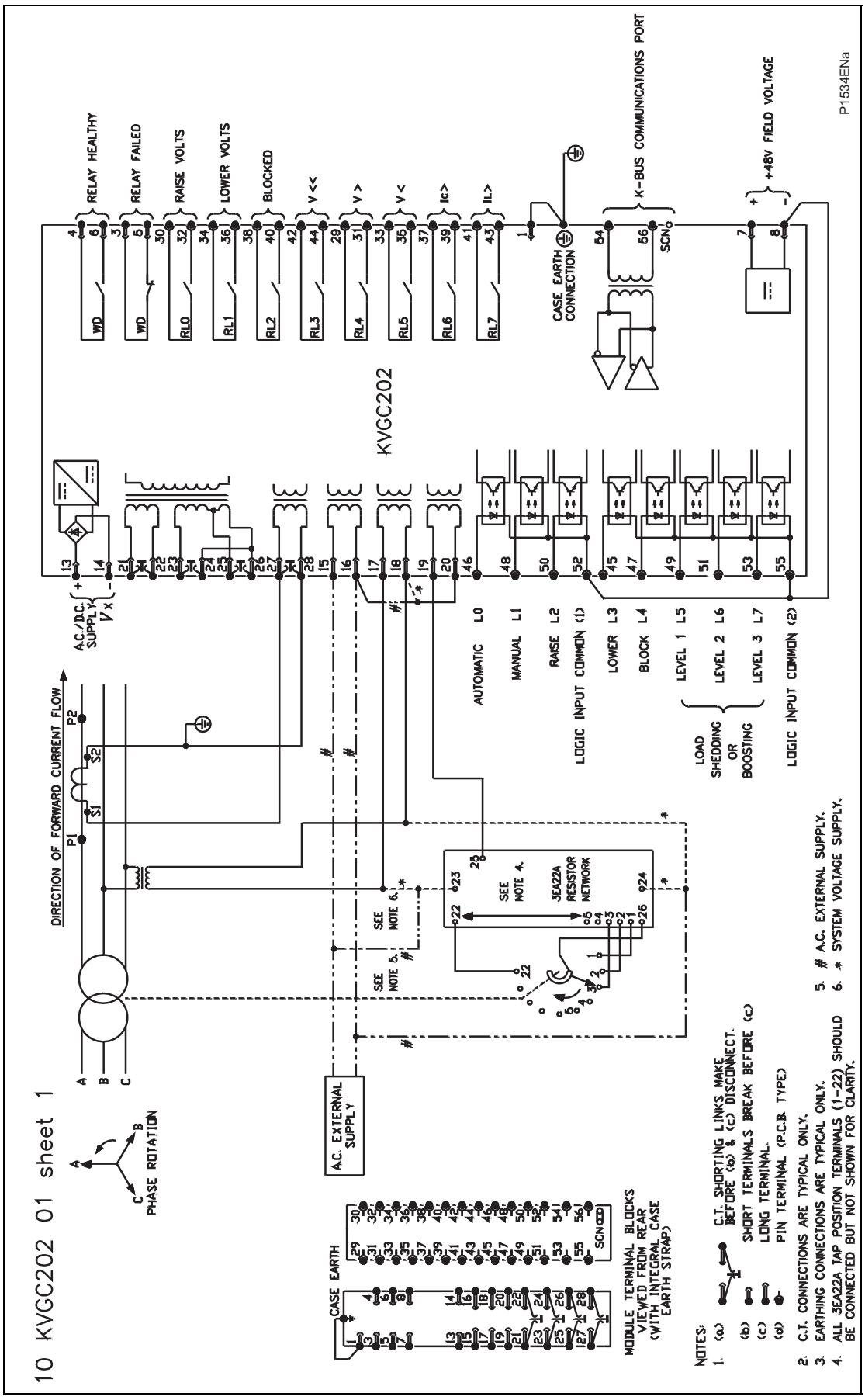

10 KVGC202 00 sheet 1
P1529ENa
KVGC202
RELAY HEALTHY
RELAY FAILED
RL0
RL1
RL2
RL3
RL4
RL5
RL6
RL7
CASE EARTH CONNECTION
K-BUS COMMUNICATIONS PORT
SCN6
+48V FIELD VOLTAGE
A.C./D.C. SUPPLY
LOGIC INPUT COMMON (1)
LOGIC INPUT COMMON (2)
L0
L1
L2
L3
L4
L5
L6
L7
DIRECTION OF FORWARD CURRENT FLOW
P1
P2
S1
S2
A
B
C
PHASE ROTATION
A.C. EXTERNAL SUPPLY
SEE NOTE 4.
SEE NOTE 5.
SEE NOTE 6.
3EA22A RESISTOR NETWORK
CASE EARTH
SCN
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL.
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY.
3. EARTHING CONNECTIONS ARE TYPICAL ONLY.
4. ALL 3EA22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
5. # A.C. EXTERNAL SUPPLY.
6. * SYSTEM VOLTAGE SUPPLY.

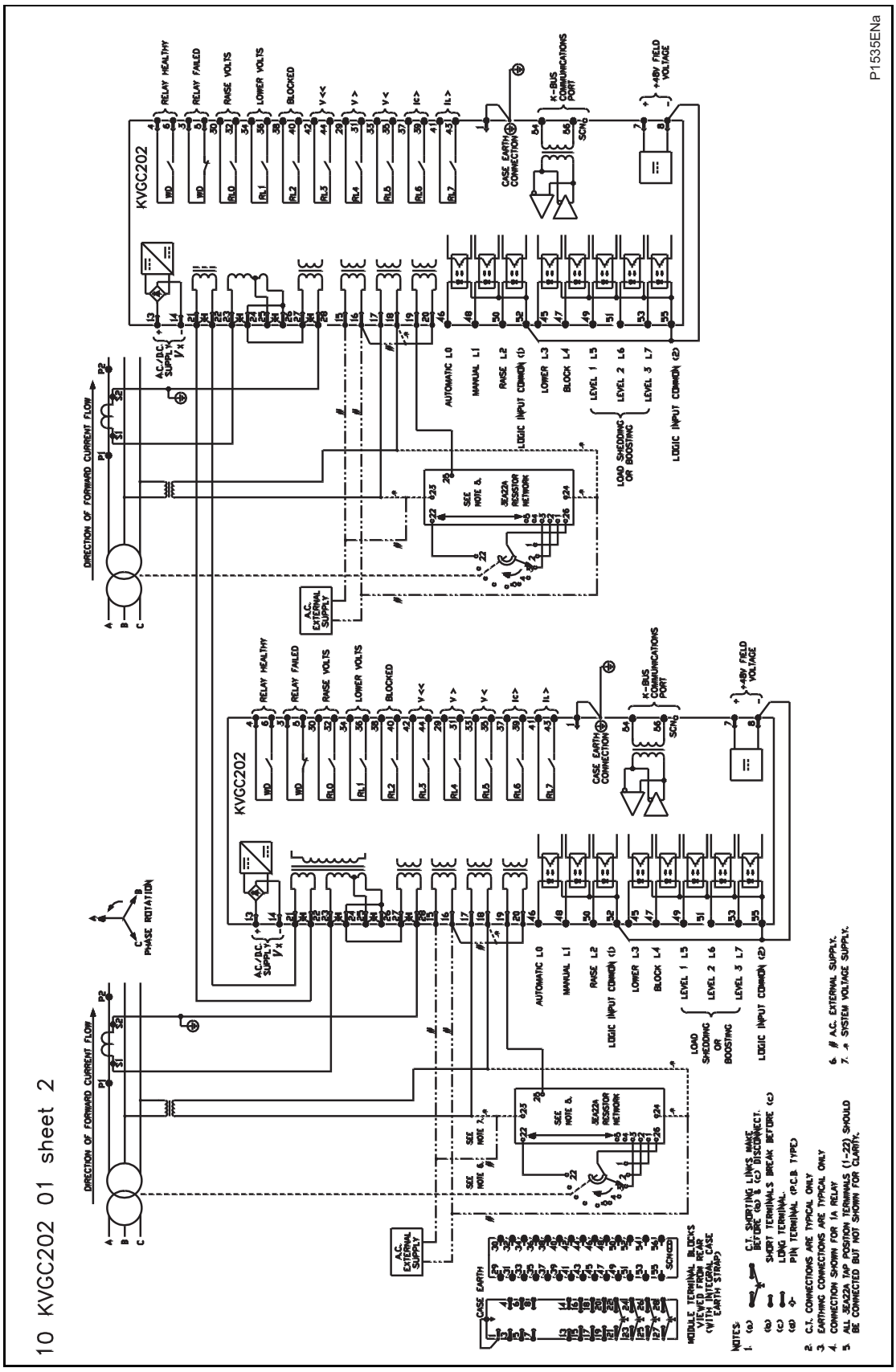

10 KVGC202 00 sheet 2
P1530ENa
KVGC202
RELAY HEALTHY
RELAY FAILED
K-BUS COMMUNICATIONS PORT
CASE EARTH CONNECTION
+48V FIELD VOLTAGE
LOGIC INPUT COMMON
A.C. EXTERNAL SUPPLY
DIRECTION OF FORWARD CURRENT FLOW
PHASE ROTATION
SEE NOTE 6.
SEA22A RESISTOR NETWORK
CASE EARTH
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. CONNECTION SHOWN FOR 1A RELAY
5. ALL SEA22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. ∗ SYSTEM VOLTAGE SUPPLY.

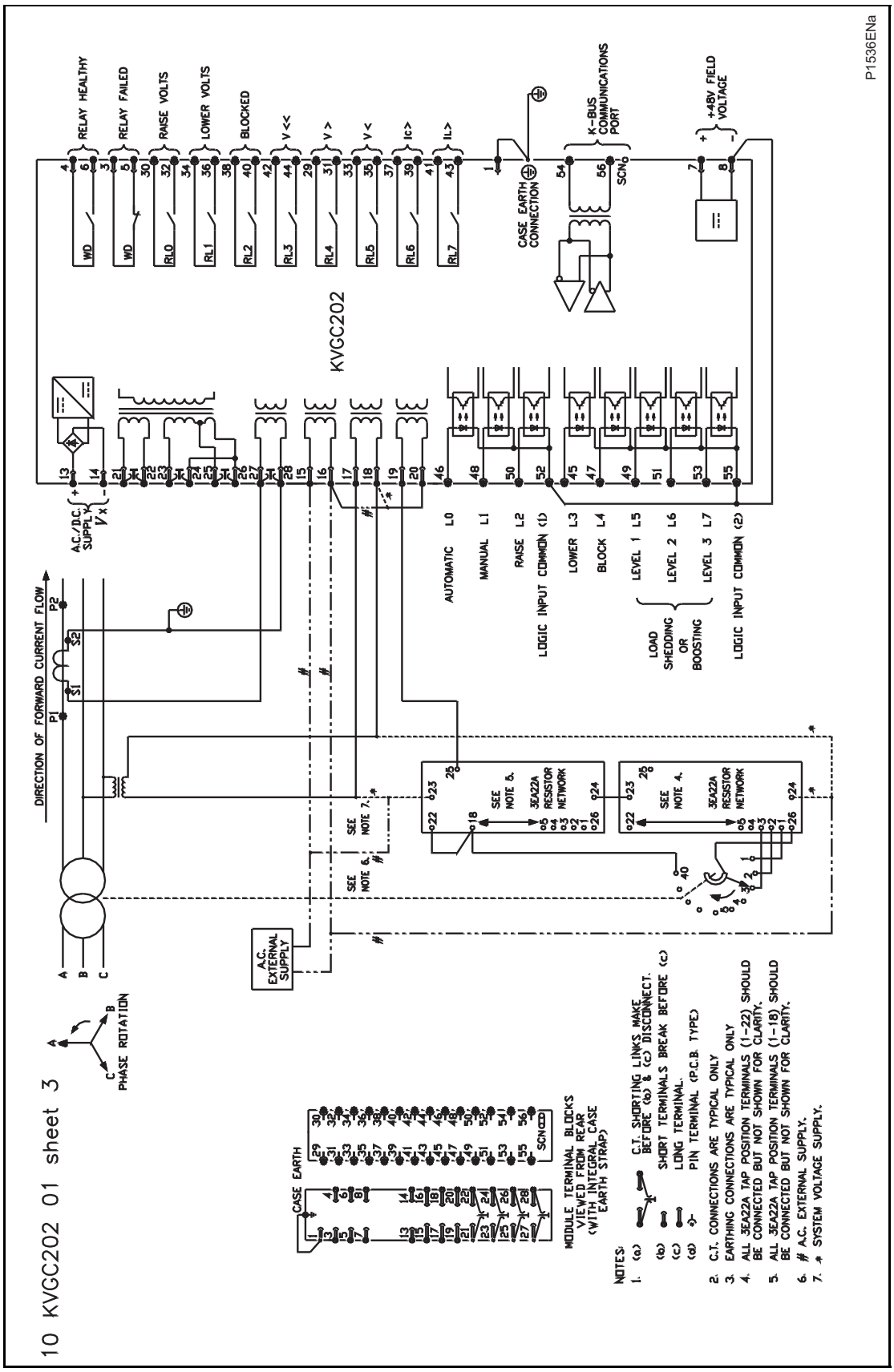

10 KVGC202 00 sheet 3
P1531ENa
KVGC202
RELAY HEALTHY
RELAY FAILED
RL0
RL1
RL2
RL3
RL4
RL5
RL6
RL7
CASE EARTH CONNECTION
K-BUS COMMUNICATIONS PORT
+48V FIELD VOLTAGE
A.C./D.C. SUPPLY
LOGIC INPUT COMMON (1)
LOGIC INPUT COMMON (2)
L0
L1
L2
L3
L4
L5
L6
L7
DIRECTION OF FORWARD CURRENT FLOW
A.C. EXTERNAL SUPPLY
PHASE ROTATION
SEE NOTE 5.
SEE NOTE 4.
SEE NOTE 7.
SEE NOTE 6.
3EA22A RESISTOR NETWORK
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
CASE EARTH
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL.
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. ALL 3EA22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
5. ALL 3EA22A TAP POSITION TERMINALS (1-18) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. * SYSTEM VOLTAGE SUPPLY.

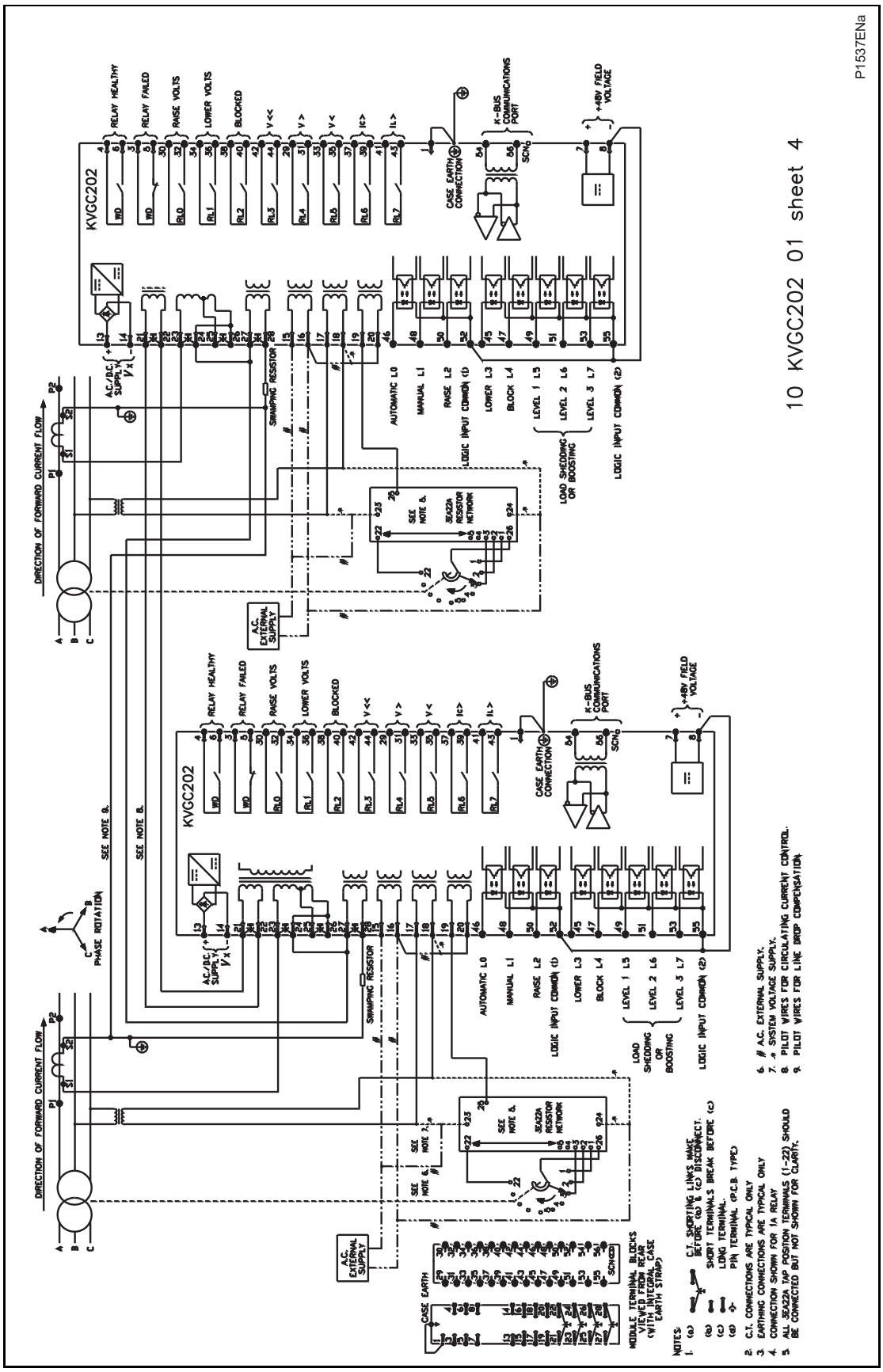

10 KVGC202 00 sheet 4
P1532ENa
KVGC202
RELAY HEALTHY
RELAY FAILED
K-BUS COMMUNICATIONS PORT
+48V FIELD VOLTAGE
CASE EARTH CONNECTION
SCN
SCN
SHUNTING RESISTOR
LOGIC INPUT COMMON (1)
LOGIC INPUT COMMON (2)
SEE NOTE 8.
SEE NOTE 8.
PHASE ROTATION
DIRECTION OF FORWARD CURRENT FLOW
A.C. EXTERNAL SUPPLY
CASE EARTH
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTERNAL EARTH STRAP)
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL.
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. CONNECTION SHOWN FOR 1A RELAY
5. ALL 22 WAY POSTION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. * SYSTEM VOLTAGE SUPPLY.
8. PILOT WIRES FOR CIRCULATING CURRENT CONTROL.
9. PILOT WIRES FOR LINE DROP COMPENSATION.

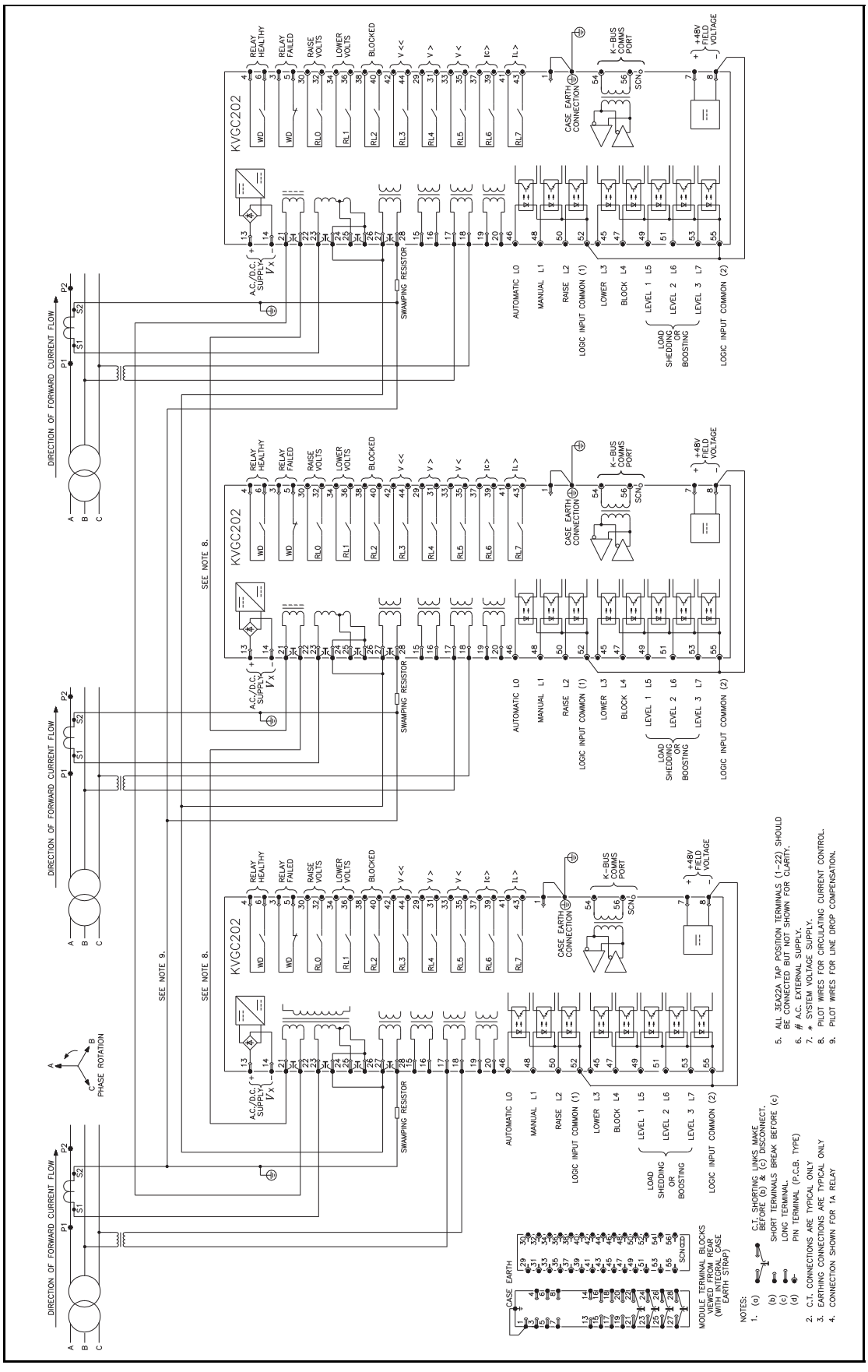

10 KVGC202 00 sheet 5
P1533ENa
KVGC202
DIRECTION OF FORWARD CURRENT FLOW
PHASE ROTATION
SEE NOTE 8.
SHUNTING RESISTOR
AC/DC SUPPLY
RELAY HEALTHY
RELAY FAILED
CASE EARTH CONNECTION
K-BUS COMMS PORT
+48V FIELD VOLTAGE
LOGIC INPUT COMMON
CASE EARTH
MODULE TERMINAL BLOCKS (WITH INTEGRAL CASE EARTH STRAP)
NOTES
1. C.T. SHORTING LINKS MAKE BEFORE (a) & (c) DISCONNECT.
SHORT TERMINALS BREAK BEFORE (c)
LONG TERMINAL
PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. CONNECTION SHOWN FOR 1A RELAY
5. ALL RELAY TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. ~ SYSTEM VOLTAGE SUPPLY.
8. PILOT WIRES FOR CIRCULATING CURRENT CONTROL.
9. PILOT WIRES FOR LINE DROP COMPENSATION


10 KVGC202 01 sheet 1
P1534ENa
KVGC202
RELAY HEALTHY
RELAY FAILED
RAISE VOLTS
LOWER VOLTS
BLOCKED
V <<
V >
V <
Ic>
IL>
WD
RL0
RL1
RL2
RL3
RL4
RL5
RL6
RL7
CASE EARTH CONNECTION
K-BUS COMMUNICATIONS PORT
SCN
+48V FIELD VOLTAGE
A.C./D.C. SUPPLY
AUTOMATIC L0
MANUAL L1
RAISE L2
LOGIC INPUT COMMON (1)
LOWER L3
BLOCK L4
LEVEL 1 L5
LEVEL 2 L6
LEVEL 3 L7
LOAD SHEDDING OR BOOSTING
LOGIC INPUT COMMON (2)
DIRECTION OF FORWARD CURRENT FLOW
P1
P2
S1
S2
A
B
C
PHASE ROTATION
A.C. EXTERNAL SUPPLY
SEE NOTE 6.
SEE NOTE 4.
3EA22A RESISTOR NETWORK
CASE EARTH
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL.
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY.
3. EARTHING CONNECTIONS ARE TYPICAL ONLY.
4. ALL 3EA22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
5. # A.C. EXTERNAL SUPPLY.
6. * SYSTEM VOLTAGE SUPPLY.


10 KVGC202 01 sheet 2
P1535ENa
KVGC202
RELAY HEALTHY
RELAY FAILED
RAISE VOLTS
LOWER VOLTS
BLOCKED
V<<
V>
V<
I£>
I£>
CASE EARTH CONNECTION
K-BUS COMMUNICATIONS PORT
+48V FIELD VOLTAGE
AUTOMATIC L0
MANUAL L1
RAISE L2
LOGIC INPUT COMMON (1)
LOWER L3
BLOCK L4
LEVEL 1 L5
LEVEL 2 L6
LEVEL 3 L7
LOGIC INPUT COMMON (2)
LOAD SHEDDING OR BOOSTING
A.C. EXTERNAL SUPPLY
DIRECTION OF FORWARD CURRENT FLOW
PHASE ROTATION
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
NOTES:
1. C.T. SHORTING LINKS MAKE BEFORE (a) & (c) DISCONNECT.
SHORT TERMINALS BREAK BEFORE (c)
LONG TERMINAL.
PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. CONNECTION SHOWN FOR 1A RELAY
5. ALL 3EA22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. * SYSTEM VOLTAGE SUPPLY.


P1536ENa
10 KVGC202 01 sheet 3
KVGC202
RELAY HEALTHY
RELAY FAILED
RAISE VOLTS
LOWER VOLTS
BLOCKED
V <<
V >
V <
IC>
IL>
K-BUS COMMUNICATIONS PORT
+48V FIELD VOLTAGE
CASE EARTH CONNECTION
A.C./D.C. SUPPLY
AUTOMATIC L0
MANUAL L1
RAISE L2
LOWER L3
BLOCK L4
LEVEL 1 L5
LEVEL 2 L6
LEVEL 3 L7
LOGIC INPUT COMMON (1)
LOGIC INPUT COMMON (2)
LOAD SHEDDING OR BOOSTING
DIRECTION OF FORWARD CURRENT FLOW
A.C. EXTERNAL SUPPLY
SEE NOTE 5.
SEE NOTE 6.
SEE NOTE 7.
SEE NOTE 4.
35A22A RESISTOR NETWORK
PHASE ROTATION
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL.
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. ALL 35A22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
5. ALL 35A22A TAP POSITION TERMINALS (1-18) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. * SYSTEM VOLTAGE SUPPLY.


P1537ENa
10 KVGC202 01 sheet 4
KVGC202
RELAY HEALTHY
RELAY FAILED
RAISE VOLTS
LOWER VOLTS
BLOCKED
V<<
V>
V<
IC>
IL>
K-BUS COMMUNICATIONS PORT
CASE EARTH CONNECTION
+48V FIELD VOLTAGE
SCN
WD
RL0
RL1
RL2
RL3
RL4
RL5
RL6
RL7
A.C./D.C. SUPPLY
SWAMPING RESISTOR
SEE NOTE 8.
SEE NOTE 9.
JEA22A RESISTOR NETWORK
A.C. EXTERNAL SUPPLY
DIRECTION OF FORWARD CURRENT FLOW
PHASE ROTATION
AUTOMATIC L0
MANUAL L1
RAISE L2
LOWER L3
BLOCK L4
LEVEL 1 L5
LEVEL 2 L6
LEVEL 3 L7
LOGIC INPUT COMMON (1)
LOGIC INPUT COMMON (2)
LOAD SHEDDING OR BOOSTING
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
CASE EARTH
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL.
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. CONNECTION SHOWN FOR 1A RELAY
5. ALL JEA22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. ^ SYSTEM VOLTAGE SUPPLY.
8. PILOT WIRES FOR CIRCULATING CURRENT CONTROL.
9. PILOT WIRES FOR LINE DROP COMPENSATION


KVGC202
DIRECTION OF FORWARD CURRENT FLOW
SEE NOTE 8.
SEE NOTE 9.
PHASE ROTATION
A.C./D.C. SUPPLY
SWAMPING RESISTOR
RELAY HEALTHY
RELAY FAILED
RAISE VOLTS
LOWER VOLTS
BLOCKED
V <<
V >
V <
IE>
IL>
CASE EARTH CONNECTION
K-BUS COMMS PORT
+48V FIELD VOLTAGE
AUTOMATIC L0
MANUAL L1
RAISE L2
LOGIC INPUT COMMON (1)
LOWER L3
BLOCK L4
LEVEL 1 L5
LEVEL 2 L6
LEVEL 3 L7
LOAD SHEDDING OR BOOSTING
LOGIC INPUT COMMON (2)
CASE EARTH
MODULE TERMINAL BLOCKS VIEWED FROM REAR (WITH INTEGRAL CASE EARTH STRAP)
NOTES:
1. (a) C.T. SHORTING LINKS MAKE BEFORE (b) & (c) DISCONNECT.
(b) SHORT TERMINALS BREAK BEFORE (c)
(c) LONG TERMINAL.
(d) PIN TERMINAL (P.C.B. TYPE)
2. C.T. CONNECTIONS ARE TYPICAL ONLY
3. EARTHING CONNECTIONS ARE TYPICAL ONLY
4. CONNECTION SHOWN FOR 1A RELAY
5. ALL 3EA22A TAP POSITION TERMINALS (1-22) SHOULD BE CONNECTED BUT NOT SHOWN FOR CLARITY.
6. # A.C. EXTERNAL SUPPLY.
7. * SYSTEM VOLTAGE SUPPLY.
8. PILOT WIRES FOR CIRCULATING CURRENT CONTROL.
9. PILOT WIRES FOR LINE DROP COMPENSATION.

APPENDIX 4

1. COMMISSIONING TEST RECORD

Date _____

Station _____ Circuit _____

Front plate information

Voltage regulating relay type	KVGC202
Model No.	
Serial No.	
Rated In	
Aux Voltage Vx	
Frequency Hz	
Rated ac voltage Vn	

0000 System data settings	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0002 Password																
0003 SD Links																
0004 Description																
0006 Plant Ref.																
0007 Model																
0008 Serial No.																
0009 Freq																
000A Comms Level																
000B Relay Address																
000C Plant status																
000D Control status																
000E Group now																
000F Load shed/boost stage																
0011 Software Ref.																
0020 Logic status																
0021 Relay status																
0022 Alarms																

0300 Control 1	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0301 CTL Links																
0302 CT Ratio																
0303 VT Ratio																
0304 In																
0305 Vs																
0306 dV																
0307 Vc(volt/In)																
0308 Vr(volt/In)																

0300 Control 1	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0309 Vx(volt/In)																
030A PF Angle																
030B tINIT DT																
030C tINTER																
030D tPULSE																
030E LSB level 1																
030F LSB level 2																
0310 LSB level 3																
0311 tTapChange																

0500 Control (2)	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0501 CTL Links																
0502 CT Ratio																
0503 VT Ratio																
0504 In																
0505 Vs																
0506 dV																
0507 Vc(volt/In)																
0508 Vr(volt/In)																
0509 Vx(volt/In)																
050A PF Angle																
050B tINIT DT																
050C tINTER																
050D tPULSE																
050E LSB level 1																
050F LSB level 2																
0510 LSB level 3																
0511 tTapChange																

0400 Logic 1	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0401 Log Links																
0402 V<<																
0403 V<																
0404 V>																
0405 t V< V>																
0406 tFAIL																
0407 Ic>																
0408 tIc																
0409 IL>																
040A IL<																
040B TpAvail																
040C TP>																

0400 Logic 1	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
040D TP<																
040E total ops																
040F ops/tP>																
0410 tP																
0411 Default Display																
0412 tTest Relay																

0600 Logic (2)	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0601 Log Links																
0602 V<<																
0603 V<																
0604 V>																
0605 t V< V>																
0606 tFAIL >																
0607 Ic>																
0608 tIc																
0609 IL>																
060A IL<																
060B TpAvail																
060C TP>																
060D TP<																
060E totalops																
060F ops/tP>																
0610 tP																
0611 Default Display																
0612 tTest Relay																

0700 Log Links	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0701 Remote																
0702 Automatic																
0703 Manual																
0704 Raise V																
0705 Lower V																
0706 Block																
0707 Level 1																
0708 Level 2																
0709 Level 3																
070A Stg GRP2																

Series 0800	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
0801 Raise V																
0802 Lower V																
0803 Blocked																
0804 UnBlocked																
0805 V<<																
0806 V<																
0807 V>																
0808 Tap Fail																
0809 Ic >																
080A IL >																
080B IL<																
080C TotalOps>																
080D FreqOps																
080E Irev																
080F RUN-AWAY																
0810 Tap Limit																
0811 Tap Odd																
0812 Tap Even																
0813 Auto Mode																
0814 Manual Mode																
0815 Select tst rlys																
0816 Test Relays = [0]																

Commissioning preliminaries

		(tick)
1.4	Serial number on case, module and cover checked	
	CT shorting switches in case checked	
	Terminals 21 and 22; 23 and 24; 25 and 26; 27 and 28 checked for continuity with module removed from case	
	External wiring checked to diagram (if available)	
1.5	Earth connection to case checked	
1.7	Test block connections checked	
1.8	Insulation checked	

Auxiliary supply checked

3.1	Auxiliary power checked			
3.1.1	Auxiliary voltage at the relay terminals		_____	V ac/dc
3.1.2	Watchdog contacts checked			
	Supply off	Terminals 3 and 5		
		Terminals 4 and 6		
	Supply on	Terminals 3 and 5		

3.1.3 Field voltage

Terminals 4 and 6 _____ V ac/dc

Metering	Applied value		Measured value	
Vs		V		A
I_C		A		A
I_L		A		A

	Grp1		Grp2	
Voltage setting Vs		V		V
Deadband setting dVs		%		%
Volts high threshold (V_{HIGH})		V		V
Volts low threshold (V_{LOW})		V		V
Measured setting (V_{HIGH} + $_{LOW}$)/2		V		V
Actual dead band ($V_{HIGH} – V_{LOW}$)		V		V

Load shedding/boosting

-3% [ ] -6% [ ] -9% [ ] +3% [ ] +6% [ ] +9% [ ]

Measured values

-3% [ ] -6% [ ] -9% [ ] +3% [ ] +6% [ ] +9% [ ]

Initial time delay (tINIT)	Grp1		Grp2	
Setting (definite)		s		s
Measured (definite)		s		s
Setting (inverse)		s		s
Measured (inverse)		s		s
Inter tap time delay (tINTER)		s		s
Setting		s		s
Measured		s		s

Line drop compensation				
Resistive compensation volts setting Vr		V		V
Mode setting [0102 STATUS]		Manual / auto		Manual / auto
Voltage setting (Vs)		V		V
Vreg [0202 MEASURE]		V		V
Measured resistive compensation Vr = reg – Vs		V		V

	Grp1		Grp2	
Reactive compensation volts setting V_{XL}		V		V
Mode setting [0102 STATUS]		Manual / auto		Manual / auto
Voltage setting (Vs)		V		V

Vreg [0202 MEASURE]		V		V
Measured reactive compensation $x = \sqrt{(Vreg - Vs^2)}$		V		V
Circulating current compensation setting V_c		V		V
Compensation (Vc)		Negative/ positive		Negative/ positive
Voltage setting (Vs)		V		V
Vreg [0202 MEASURE]		V		V
Measured circulating current compensation Vc = Vreg – Vs		V		V

Supervision

Undervoltage detector (V<)				
Undervoltage setting		V		V
Value measured		V		V
Overvoltage detector (V>)				
Overvoltage setting		V		V
Value measured		V		V
Load current detector (I_L)				
Load current setting		A		A
Value measured		A		A
Circulating current detector (I_C)				
Circulating current setting		A		A
Value measured		A		A
Alarm (tFAIL)		s		s
LOAD check				
Volts at receiving end		V		V
Volts low lamp when Vs is set at		V		V
Volts high lamp when Vs is set at		V		V
Average Vs (should ≈ volts at receiving end)		V		V

Commissioning Engineer

Customer Witness

Date

Date

Alstom Grid

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